Lexical/semantic organisation in bilingual and monolingual infants

by

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Abstract

Previous studies show that bilingual infants are slower in developing phonology and tend to experience some difficulties in acquiring some grammatical rules. Furthermore, as compared to their monolingual peers, bilingual infants tend to have less vocabulary. This thesis set out to explore how bilingual infants organise the lexical information in their two languages. Specifically, we examined the lexical-semantic relationships between words within and across languages using a word-to-word priming paradigm. The thesis sought also to uncover any relationship between semantic priming effects and the size of vocabulary. Vocabulary measures such as the BPVS II, the SETK, and the Oxford CDI were used in the experiments, along with an experimental design close to that used in Styles and Plunkett (2009) and Arias-Trejo and Plunkett's (2009) studies, based on the Intermodal Preferential Looking (IPL) paradigm. The basic design was that the infants were presented with a prime word (e.g. 'dog') followed by a target word which was related either semantically to the prime (e.g. 'cat') or not (e.g. 'bus'). Immediately thereafter, we presented two images, depicting the target and a distracter, and monitored the looking times towards the images.

In Experiment 1, we tested whether upon hearing related prime and target words, as compared to unrelated pairs, 30 month old monolingual infants preferred to look at the target more than the distracter image. This constituted a benchmark priming effect. In Experiment 2, we examined whether the presence of the target word was necessary for a priming effect to occur. The results demonstrated an

effect of semantic priming in the word-word condition (Exp.1) but no semantic priming effect was found in the word-image condition (Exp.2).

Experiment 3 investigated, in each of their languages, the semantic priming effect in bilingual 30-month-olds (Arabic-English). The overall result revealed a significant semantic priming effect along with a different pattern in Arabic and English.

Experiment 4 was designed to investigate, in a cross-linguistic design, semantic priming in bilingual 18-month-old infants and to address the symmetry between forward (L1-L2) and backward (L2-L1) priming. The overall results showed no semantic priming effect; however, infants showed a non-significant tendency for forward (L1-L2) over backward (L2-L1) priming.

As controls for the previous experiments, in Experiments 5 and 6 we examined monolingual and bilingual 18-month-olds to explore whether a priming effect could be obtained only in English. The results showed no semantic priming effect and no strong evidence of a naming effect.

All the findings suggested that hearing words activated automatically some other words which, in both monolingual and bilingual infants, were related semantically around 30 months of age, but were not found at 18 months in either population. Despite what is reported often about a delay of language in bilingual children, these findings suggest that, although they show a smaller size of vocabulary in each of their languages when compared to monolingual infants, bilingual infants may build the semantic relationship between words at the same time as their monolingual peers, and with similar word-to-word relations.

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Chapter One

Introduction

More than a third of infants in the world are bilingual or multilingual (Grosjean, 2010). It is difficult to find a community or group free of bilingualism; it exists in most schools, age groups, and even in most classrooms (Grosjean, 1982). In some countries, a large portion of the population is considered to be bilingual, such as Canada, Belgium and Switzerland. The number of children in bilingual families is increasing quickly due to immigration (Hernandez, Denton & Macartney, 2008), or because they reside in bilingual families or bilingual societies (Place & Hoff, 2011). This can also happen over time because of shifts in family structure, child carers, nursery care, or a move to another environment (Paradis, 2010). For example, Lindsay et al. (2002) report that 10-24% of the visitors to speech and language therapy services in England and Wales are bilingual children and sometimes this percentage may reach up to 25-49%.

Typically, children have no difficulty acquiring two languages at the same time (Hoff et al., 2012). As a matter of fact, bilingual and monolingual children produce their first words at almost the same time (Bosch & Sebastián-Gallés, 2003; Petitto et al., 2001). However, studies over the last three decades have tried to determine whether exposure to two languages has an effect on language development. Findings relating to the similarities and differences between bilingual and monolingual children in language development are not clear (Poulin-Dubois, Blaye, Coutya & Bialystok, 2011). On one hand, some studies indicate that bilingual children have a smaller vocabulary than their monolingual peers (Bialystok & Feng, 2009; Hoff & Elledge, 2005; Portocarrero, Burright & Donovick, 2007;

Rescorla & Achenbach, 2002; Vagh, Pan & Mancilla-Martinez, 2009). Paradis (2010) argued that bilingualism has an effect on language development due to the fact that the proportion of exposure to each language is less when compared to the exposure experienced by monolingual children. On the other hand, bilingualism has also been found to have no negative influence, and learning two languages does not mean a delay in language development or differences in size of vocabulary between bilingual and monolingual children (Hammer, Davison, Lawrence & Miccio, 2009; Junker & Stockman, 2002; Pearson, Fernández & Oller, 1993).

The majority of language assessment tests that have been used to collect data about bilingual children were built to evaluate the language ability of monolingual children. It is common practice to translate and reuse them to assess bilingual children, which may lead to invalid assessments of language development in bilingual infants (Kester & Peña, 2002; Rosselli, Ardila, Navarrete & Matute, 2010). Using this approach, it appears to be quite well established that bilingual children's vocabulary development lags behind that of monolingual children during their first few years of life (e.g., Rescorla & Achenbach, 2002).

The nature of linguistic representations in bilingual adults has been the subject of wide ranging discussion over the last two decades, with the central concern being about the organisation of lexical memory across the two languages (Durgunoğlu & Roediger, 1987; Grainger, Midgley & Holcomb, 2010; Holm & Dodd, 1999). Amongst the most influential models, the Bilingual Activation Model (BIA, Dijsktra & Van Heuven, 2002) assumes that words from two languages are accessed at the same time but are related to two language nodes, one for each language, so that they activate words from the same language and inhibit words in the other

language (Grainger et al., 2010; Kroll & Tokwicz, 2005). The Revised Hierarchical Model which is a model of the unbalanced bilingual, proposes that the two languages share the same conceptual level (Brysbaert & Duyck, 2010), but that concepts in L2 are mediated by access to L1 words (through translation equivalents), whereas L1 words directly connect to meaning (Kroll, Van Hell, Tokowicz & Green, 2010). However, more research is needed to understand how bilingual children organise information in both languages (Cui, 2009; French & Jacquet, 2004; Zhao & Li, 2010). Indeed little is known about the early semantic organisation in the bilingual lexicon: do children learn their first words as isolated "semantic islands", and develop connections with an increasing lexicon, or do they start by linking words to one another from the onset of lexical development? (Arias-Trejo & Plunkett, 2009, for monolinguals). Some researchers suggest that bilinguals code the two languages in one common system (Francis, 1999; Klein, Milner, Zatorre, Zhao & Nikelski, 1999), possibly depending on the meaning of the words and the processing levels, so that the knowledge is retrievable (Durgunoğlu & Roediger, 1987). On the other hand, bilingual children may store each language independently in specific systems (Dehaene et al., 1997; Durgunoğlu & Roediger, 1987; Holm & Dodd, 1999; Mueller Gathercole, 2007; Pearson, Fernandez & Oller, 1995).

The aim of this thesis is to provide some insight into the structure of the bilingual lexicon in young children, by examining semantic relations between words within and across languages. In particular, we will explore the strength of semantic priming between spoken words both within and across languages, and examine the symmetry between forward (L1 to L2) and backward (L2 to L1) priming. We will also examine how these priming effects relate to the size of the lexicon in

comprehension and production, and will attempt to use or adapt, when possible, vocabulary assessment tools in English and the Additional Language.

To fully grasp the implications of this project, there are a certain number of areas that need to be addressed in the following review. A literature review of research on bilingual children will be presented in some detail, focusing on vocabulary development, and semantic and lexical organisation in bilingual children. This will be followed by a review of the research on monolingual children covering the same topics. Then a series of 6 experiments will be presented, conducted to assess the effect of lexical/semantic priming on bilingual and monolingual children aged 18 to 30 months.

To avoid any confusion, we will first define the most important concepts in this research. Firstly, lexical relation refers to how a name is associated with an object in the surrounding environment. For example, if a child hears the word 'chair', the concept of chair will be activated in her mind. Second, semantic priming refers to an empirical task in which a prime word is displayed in isolation or in a carrier phrase before another, target word, which shares any kind of relation with the prime word (phonological, semantic, syntactic..). This typically results (in adults) in faster reaction times to identify the target as compared to a situation where the prime has no relation to the target.

Within semantic relations, thematic relations refer to the classification on the basis of the recurrence of the objects together, regardless of whether this is based on temporal or spatial frequency, but may also be related to a complementary function or object, such as dog-bone or fork-knife. Finally, taxonomic categorisation refers to how children sort a word with other words that belong to

the same category, and this category may be narrow, such as farm animals (sheep, horse) or much broader, such as mammals (horse, whale).

Chapter two

Literature Review

Language Development in Bilingual Infants

The aim of this literature review is to provide a clear illustration of what is different between preschool language development in monolingual and bilingual children, and whether differences in linguistic background have any effect on language development. More than the effects of bilingualism on non-linguistic abilities (see a review by Bialystock, 2009), we are interested here in the impact it has on the language development, and particularly, in the development of the lexicon, both in terms of size and organisation.

Infants start to recognise some vocabulary at around 6 months of age and really comprehend the meanings of words at over 9 months of age (Hoff, 2009). They usually produce their first word at around 1 year of age (Harley, 2010), and by 2 years of age they start to say two or three words together as sentences (Radford, 2004), which is taken as evidence of syntactic processing. Morphology develops after the beginning of syntax, usually from the age of two to three years (Ambridge & Lieven, 2011).

In general, vocabulary development is slow at first. Infants need about 6 months to get a productive lexicon of 50 words, and this tends to occur between around 1 year and 6 months of age and 2 years of age. Further to this, infants' first sentences are simple and contain much incorrect grammar. After two years of age the majority of children show a relatively rapid increase in size of vocabulary (Hoff, 2009).

In effect, infants can acquire not just one, but a couple of languages at the same age (Bosch & Sebastián-Gallés, 1997). There are two views on the qualitative impact of bilingualism on language development. The first view is known as bilingualism deficiency, which indicates that bilingual children may develop their two languages to a lesser extent than their monolingual counterparts, due to the processing burdens imposed on them. Indeed, they have to deal with two types of inputs: two vocabularies, two sets of syntactic rules, two prosodic systems and segmental phonology, etc (Oller, Eilers, Urbano & Cobo-Lewis, 1997).

From this perspective, according to Verhallen and Schoonen (1998), young second-language learners are faced in class with the dual task of acquiring the vocabulary of the foreign language to interact with other people and at the same time, using this second language in cognitively difficult learning tasks. Moreover, several researchers have brought to light a negative type of interdependency, in which the learning of another language may be harmful to the further development of the maternal language and vice versa. The learning and usage of a new language (mainly the mainstream language) might be at the expense of the use and development of the native language (the language least prevalent). The end result would be a weak proficiency in the maternal language (as cited in Leseman, 2000).

The second view on the effect of bilingualism on language development is referred to as the Interdependency Hypothesis, and suggests that there is an achieved proficiency in one language and strengths in the learning of the other, on the condition that there is enough exposure and motivation to acquire the other language (Oller et al., 1997).

Coherent with the Interdependency Hypothesis, a number of studies suggest that the exposure to two languages or more during infancy leads to an increased

awareness of the grammatical and phonological aspects of language (Eviatar & Ibrahim, 2000).

Research into bilingual development and second language acquisition has traditionally focused on general language skills and structural-grammatical milestones. Recently however researchers have paid particular attention to vocabulary, specifically to the lexical-conceptual development of infants' progress in a bilingual context, which is considered as one of the main and central determinants of their academic achievement and second language acquisition (Leseman, 2000). In what follows we will review the impact of bilingualism on grammatical and lexical development.

Words and Grammar in Bilingual Children

Bilingually raised infants find a way very early on to distinguish between their two languages, probably on the basis of prosodic features, allowing them to acquire the two sound/grammatical systems independently. This was shown by Bosch and Sebastián-Gallés (2001) who tested 4 month-old children's ability to identify their native language. Children were Catalan/Spanish bilinguals or monolinguals in Catalan or Spanish. Using a familiarisation-preference procedure the authors provided the first evidence that infants growing up in bilingual surroundings can distinguish between their two languages although these are rhythmically close languages such as Spanish and Catalan, a finding which challenges the view that bilingual infants would be late in acquiring important phonological distinctions. This shows that from the onset of language learning, infants are well equipped to sort out languages in their environment in order to build coherent, separate linguistic systems.

Regarding grammatical development, research tends to show that bilingual children are slightly delayed when compared to monolingual ones. Mueller Gathercole (2002b) tested Spanish-English bilingual and monolingual children in a grammatical and ungrammatical sentences judgment task. In each language eight sentences were selected: half of them had an overt complementiser, and the other half did not. Each sentence was judged on whether it was acceptable or not. The findings showed that the bilingual children, in contrast to their monolingual peers, lagged behind in the acquisition of these elements of grammar: bilinguals performed less well than monolinguals on test sentences involving two measures, corrections and judgments of sentences. In addition to this, bilinguals performed less well with ungrammatical sentences than with grammatical ones. However, unexpectedly, the bilingual children who came from low socio-economic status (SES), and were registered in two-way schools (50% English and Spanish) or were from families speaking one language only (Spanish), performed better than the bilinguals coming from a high SES.

Mueller Gathercole (2002a) also looked at the acquisition of a particular grammatical structure of the first language, which was not shared with the grammar of the second language. Spanish-English bilingual and Spanish monolingual children coming from a middle and upper-middle social-economic status were tested in a grammatical judgment task. Each group was presented with eight sentences, half of them were grammatical and the other half was not. The experimenter asked the children to decide which sentence was acceptable. In instances when they considered any sentence unacceptable, the children were asked to correct it. In general, bilinguals lagged behind monolinguals, particularly in the recognition of ungrammatical sentences.

To investigate the links between grammatical development and vocabulary knowledge, Kohnert, Kan and Conboy (2010) examined a group of bilingual Hmong-English children (Hmong language is spoken by the Hmong people of Sichuan, Yunnan, Guizhou, Guangxi, northern Vietnam, Thailand and Laos), aged from 3 to 5 years. The participants were divided into two groups, with half of them performing an English session first and a Hmong session second, and the second group performing the Hmong session first and then the English session after. The interval between the two language tasks was approximately 2 weeks. The experimenter told the child a story from a book, and pointed to the appropriate pictures using one of the two languages. Then the child was asked to retell the story to another person who was a native speaker of the language used in the task. The results indicated that the children produced fewer words in English than in Hmong, and produced longer sentences in Hmong than in English. Overall the results showed a positive relationship between children's amount of vocabulary and their grammatical knowledge.

Finally, Marchman, Martínez-Sussmann and Dale (2004) studied the relationship between words and grammar in 113 bilingual American infants (English-Spanish) at 23.5 months of age. They used a language exposure questionnaire to control for the amount of exposure to each language, the MacArthur Communicative Development Inventories CDI, and its Spanish version (El Inventario del Desarrollo de Habilidades Comunicativas: Palabras y Enunciados [IDHC], Fenson et al. 1993; Jackson-Maldonado et al., 2003). Developmental grammar was examined using three methods: firstly, parents reported the three longest sentences produced by their child recently. Secondly, 37 pairs of phrases were presented to parents and they were asked to point to a similar phrase that they had heard from their child;

and lastly, recordings were made during a free play session from 26 infants whom were selected from the main sample. These sessions lasted on average half an hour for each language, during which one of the parents participated together with the examiner. Results suggested that there was a significant positive correlation between length of sentences and vocabulary in both languages. In addition a strong correlation was found between the number of different words produced and the length of sentences in the free speech task in Spanish. Again, these results showed a positive correlation between vocabulary size and mastering of grammar.

Altogether these studies suggest that in a bilingual child (just as in a monolingual child), development of grammatical skills are strongly related to vocabulary development, which suggests that for assessment purposes in bilingual toddlers, measuring vocabulary size alone might be a good indicator of language achievements. They also suggest that the delay experienced in the acquisition of grammatical rules might originate from a slower pace of lexical development learning.

Phonological Development in Bilingual Children

The emergence of babbling in bilinguals and monolinguals seems to be equivalent in terms of calendar and quantity, as seen in a longitudinal study by Oller et al. (1997) who recorded 73 Spanish-English bilingual and English monolingual children aged from 4 to 18 months of age. The parents were asked to contact the lab once their child had started to produce well-structured canonical syllables. From then on, the laboratory assistant recorded samples of free vocalization over a few sessions to collect almost 70 utterances. Sessions for bilinguals were divided into two parts; a first part was performed in English and a second part in Spanish. During these sessions, the parent and the assistant were speaking the same

language. The results showed that the onset of canonical babbling in bilinguals and monolinguals was only a few days apart. There was also no difference between bilingual and monolingual children in vocal performance. These findings suggest that the exposure to two languages at the same time did not have an effect on the emergence of pre-linguistic speech.

However regarding the acquisition of phonological information, results usually show that bilingual infants' acquisitions are late, or at best occur at the same time than those of monolingual children. For example, Bosch and Sebastián-Gallés (2003) used the modified version of the familiarization preference procedure (Jusczyk & Aslin, 1995) to test 4 and 8 month old Spanish monolingual, Catalan monolingual and Spanish-Catalan bilingual children's ability to discriminate the Catalan /e/ versus /ɛ/ contrast. They also tested an additional group of 12-month-old bilinguals. The procedure included a familiarisation stage, whereby participants were presented with 12 dissimilar tokens. Half of the participants were presented with /'deði/ and the second half with /'dɛði/. The test stage consisted of 4 test trials with new tokens, two of them with the same vowel used in the familiarization stage and the other two with the contrastive vowel. The results indicated that there was no significant difference between the three groups (Spanish monolingual, Catalan monolingual and Spanish-Catalan bilingual) at 4 months of age, with all children able to detect the vowel change. However, only the 8-month-old Catalan monolingual group succeeded at discriminating the vowel contrast, while the bilingual children were not successful until they reached 12 months of age. The delay in the time course of phonetic discrimination in bilinguals suggested that bilinguals follow a different developmental pattern.

Additionally, Sundara, Polka and Genesee (2006) used a modified version of the conditioned head-turn procedure to examine the proficiency of discrimination of the English /d/-/ð/ contrast, a notoriously difficult contrast to acquire in English due to its distribution. In this study three groups of children were compared: monolingual English, monolingual French and bilingual French-English. Demographic factors including their language background and age were also assessed to investigate whether these would have an effect on phonetic discrimination. Furthermore, the data from this experiment were compared with data from monolingual children and adults from the work of Polka, Colantonio and Sundara (2001) to trace the developmental pattern of phonetic discrimination ability in monolingual and bilingual children. The stimuli involved two groups of naturally produced word pairs, /bot/-/vot/ (boat–vote) and /doz/-/ðoz/ (doze-those), the b-v pair being used as a control for task performance. The Peabody Picture Vocabulary Test (PPVT, Dunn & Dunn, 1981) was used to evaluate children's receptive language ability. The results indicated that 4-year-old bilingual children, just like the French monolinguals, could not discriminate the /d/-/ð/ contrast, whereas the English monolingual children succeeded. In addition, no significant differences were found between bilingual adults and monolingual English adults in discriminating the English /d/-/ð/ contrast, with bilingual adults performing better than the 4-year-old bilingual children. Altogether, these findings suggest that the children exposed to two languages differed in the age of acquisition of some phonemic contrasts (see also Bosch & Sebastián-Gallés, 2005; Sebastián-Gallés & Bosch, 2009; Sebastián-Gallés, Echeverría & Bosch, 2005), perhaps because they have altogether less exposure in each language.

However, in a study by Sundara, Polka and Molnar (2008), children's discrimination of dental (French) and alveolar (English) phonetic contrasts were compared in 96 children divided into three groups (monolingual English, monolingual French and French-English bilingual children). Stimuli were made up of six English and six French contrasts and a detailed parental questionnaire was used to evaluate children's language exposure. The experimenters used a partially infant-controlled visual habituation procedure to test the participants. The results showed that participants correctly discriminated all contrasts in their language(s) at 6-8 months of age. At 10-12 months, bilingual children were consistent with their English monolingual peers and discriminated the English contrasts, whereas French children expectedly failed to do so. These results suggested that the development of phonetic perception in bilingual children is not necessarily slower than that of monolingual children. One explanation for the delay observed in the acquisition of some vowel (Bosch & Sebastián-Gallés, 2003) or consonant contrasts (Sundara et al., 2006) is that these specific contrasts were difficult to retrieve due to their complex distribution (for example, /ð/ occurs mainly at the onset of function words in English, such as 'that' or 'the', which are not the most salient portions of speech).

In summary, the picture so far is that bilingual children do seem to lag behind in studies examining phonological abilities (see Bosch & Sebastián-Gallés, 2003; Sundara, et al., 2006), or at best show some equivalent calendar of acquisition (Sundara et al., 2008). In what follows we will focus on bilingual children's vocabulary development.

Vocabulary Development in Bilingual and Monolingual Children

Of direct interest to our study is the examination of vocabulary development in young bilinguals, as compared to monolinguals. As we will see throughout this review the majority of studies do find a delay in bilinguals, as predicted from the observed delay in grammatical development (Mueller-Gathercole, 2002a), and as anticipated from data showing a delay in phonological acquisitions (Sundara et al., 2006). However when the size of the two lexicons is taken into account, the delay is not necessarily as apparent (see Pearson et al., 1993). We will organise this review following a chronological age in children's development.

Hoff and Elledge (2005) tested 39 bilingual children (exposed at home to any language other than English) and 63 English monolingual children between the ages of 1 - 4 and 2 - 6 years. Researchers matched members of the sample by age, gender and the educational level of parents. Information about the vocabulary and grammatical development of children in English were provided by children's parents using the CDI. Regarding the Additional Language, the researchers collected information about family demographic characteristics using interviews that consisted of 100 items about the home language environment. The results showed that, all other factors being equal, bilingual children were slightly slower than their monolingual peers in the acquisition of vocabulary for each language. However, the results did not reveal any delay in grammatical development in bilingual children.

Other strong evidence for the delay in bilingual's vocabulary development, but no support for the lag in grammar (at least, as measured by the CDI, as above) was reported by Hoff et al. (2010). Language development was examined in a sample of 47 Spanish-English bilingual and 56 English monolingual children aged 1.10, 2.1

and 2.6 years from families with a high socio-economic status. Vocabulary was measured with the McArthur Bates CDI (words and sentences) and its Spanish version (IDHC, Jackson-Maldonado et al., 2003). Results indicated that the vocabulary score of monolinguals was higher than that of bilinguals (see also Oller, Pearson & Cobo-Lewis, 2007) and that the difference increased over time, probably due to a floor effect in the younger children. In addition monolingual children were better in their grammatical productions. However no difference was found between bilinguals and monolinguals when the total vocabulary of the two languages was taken into account. The results reveal that infants who learn two languages score lower than their peers in their lexical outcome in each of the two languages if their overall ability across the two languages is ignored.

Pearson et al. (1993) also reported similar results by testing 25 English-Spanish bilingual and (mostly English) monolingual infants between 8 and 30 months of age using the MacArthur CDI (1989), to evaluate the receptive and productive aspects of infants' vocabulary in their first and/or second language. The results suggested that the productive capabilities of bilingual infants appeared more balanced, divided between two languages, in spite of bilinguals having a smaller vocabulary size in each of their languages as compared to monolingual infants. However, the total vocabulary in the two languages of bilingual children was comparable for monolingual and bilingual infants.

However the delay in vocabulary development, when considering each language separately, is clearly established. For example Vagh et al. (2009) examined 85 Spanish-English bilingual and English monolingual children from 2 to 3 years of age on their English productive vocabulary development, also using parental and teacher reports. The MacArthur-Bates CDI was used in this longitudinal study and

the results suggested that bilingual children had slower development rates than their monolingual counterparts.

Another example where the researchers focused on vocabulary development with a wider age range of children and a bigger sample size was conducted by Rescorla and Achenbach (2002) who tested 278 English monolingual and African, Spanish, Asian and other mixed bilingual infants between 18 and 35 months of age using the Language Development survey (LDS). The results suggested that the infants from bilingual families obtained considerably smaller vocabulary scores in the LDS than infants from monolingual families, which was surprising given the similarity in the mean length of utterances. It may be that the development of infants in bilingual families is similar to that of their monolingual peers with regard to combining words, but that to some extent they are slower in learning vocabulary.

The vocabulary development delay seems to be found even after the early years, as shown for example by Bialystok and Feng (2009) who conducted an experiment on 20 Cantonese, Arabic, Korean, Spanish, Farsi, Tagalog or Tamil-English bilingual and 20 English monolingual children of approximately 7 years of age. The children's parents filled out a questionnaire about the linguistic background of their children. A Peabody Picture Vocabulary Test III was used and to assess working memory abilities the experimenter asked participants to repeat numbers in the same order as they were presented using a forward digit span task. The task started with a series of numbers and the length of the series rose with each trial. The task continued until the participant was unable to repeat the correct numbers. Then in a second task, examiners asked children to repeat a series of numbers, but here children were asked to reorder them from small to large (ascending sequence). Finally, in a proactive interference task four lists of words were

presented in English, where each list included five words. The participant heard and saw the words, and then they repeated every word as they were presented. The examiners asked them to remember the words that had just been presented. The results revealed that bilinguals have a smaller vocabulary size in each language than their monolingual peers. However, they did show similar performance in the working memory task when they were asked to recall words in lists.

Finally, Yan and Nicoladis (2009) compared 20 French-English bilingual and 25 English monolingual children aged 7-10 years in their ability to access their lexicon. The PPVT III (Dunn & Dunn, 1997) in English and its French equivalent "Echelle de vocabulaire en images Peabody" (EVIP, Dunn, Theriault & Dunn, 1993) were used. The picture naming task involved 50 pictures, most of which were objects that were displayed on a computer. After the picture naming task the participants were tested on a comprehension test which consisted of 50 target pictures where each target picture was presented with 3 distracter pictures. The first distracter picture was seen in the previous task, the second distracter was semantically related to the target word and the third distracter had no relation to the target word. The results revealed that there was no significant difference between bilingual children and their monolingual peers in PPVT vocabulary score. However the monolingual children were better than bilinguals in the picture naming task. The results demonstrated that the difference between bilingual and monolingual peers was unimportant in receptive vocabulary; however there were important differences between them in lexical access for production where monolinguals produced significantly more target names in the picture naming task.

In summary, the above findings illustrate the effect of exposure to two languages on vocabulary size, and indicate that there are some contradictory results regarding the effect of bilingualism on receptive and productive vocabulary (see Bialystok & Feng, 2009; Vagh et al., 2009; Yan & Nicoladis, 2009) and on grammatical development (see Hoff et al., 2010; Hoff & Elledge, 2005).

It is important to note however that bilingualism does not necessarily result in delays in the acquisition of reading and writing, as it is generally the case that the size of vocabulary is a good predictor of reading abilities in children. Hammer et al. (2009) aimed to verify the effect of first language on the vocabulary of 4-year-old bilingual children and the emergence of reading and writing. Their study consisted of 72 English-Spanish bilingual children and their mothers, who all spoke Spanish at home. The researchers evaluated the English and Spanish vocabulary of children in the autumn and spring of each year, over a three year period. In the first session, the language skills of participants were evaluated in English, and in the second session their ability was evaluated in Spanish. Furthermore, two versions (Spanish and English) of the PPVT III (English, Spanish), the Test of Early Reading Ability-2 (TERA-2) and a Language Usage Questionnaire were used in this study. The results indicated that the use of a first language had no negative effect on the second language vocabulary development of children at that age, nor did it impact on their emergent literacy abilities.

So far, the general findings point to lower vocabulary in young bilinguals than in their monolingual peers, which could be explained by their lower amount of exposure to each of their languages, but also by different strategies in word learning. For example, as found by Mattock, Polka, Rvachew and Krehm (2010), bilingual children may be better at learning new words when phonological

variability is presented in word learning tasks. These authors tested 48 English monolingual, French monolingual and English-French bilingual children of approximately 17 months of age, and used a language exposure questionnaire, together with the auditory presentation of pseudo-words, for instance /bowce/, /bos/, /gowce/ and /gos/. These pseudo-words were produced in an English and French pronunciation (by native speakers). The researchers used the Switch paradigm developed by Stager and Werker (1997) for testing word learning, which is as follows: when participants focus on the flashing red light that appears at the centre of the presentation screen, a trial begins and a picture paired with an auditory stimulus is presented. Following familiarisation with two of these object/label pairs, participants are presented with two test trials. In the first one, one of the initial word-object pairings is displayed. In the second, a switch trial is presented wherein a familiar word and a familiar object which were not presented together are now paired. The results from this study showed that French-English bilinguals at 17 months of age looked longer to switch vs. same trials, whereas the monolingual children did not. They suggested that bilingual 17-month-old children show more aptitude than their monolingual counterparts in certain word learning situations. Monolingual children might learn to process a less diverse set of pronunciations when assimilating new vocabulary and knowledge, in contrast to their bilingual counterparts. The researchers proposed that the bilingual toddlers are possibly more sensitive to the vocabulary's surface form than their monolingual counterparts.

Another example of differences in word learning strategies between bilinguals and monolinguals is found in Byers-Heinlein and Werker (2009) who explored the effect of language background on the development of a word-learning heuristic,

specifically the disambiguation of novel nouns through the Mutual Exclusivity constraint. They examined three groups of 17-18 month old children acquiring a number of different languages, such as, English monolinguals, bilinguals exposed to a language other than English and trilinguals exposed to more than two languages other than English. In their first experiment involving 42 participants, they used the preferential looking technique. The stimuli involved four objects, one of them was novel and others were familiar (ball, car and shoe). The task consisted of 24 trials of two images presented side by side, evenly distributed on the four blocks; the first and third blocks involved known-known trials, where both the target and distracter were known to the child, whereas the second and fourth blocks involved known-novel trials, where one picture depicted a known word and the other a novel, unknown, object. The picture pair was displayed in silence for 3000 milliseconds, whereby the baseline preference of children for each picture could be measured. Then the auditory stimulus which labelled one of the pictures was presented, after which the pictures remained in silence until the end of the trial for a total duration of 9.5 s. The MacArthur-Bates CDI (Dale & Fenson, 1996; Fenson et al., 2007) was used to estimate English vocabularies. In the second experiment, 16 children were tested using a procedure similar to that of the previous experiment, with the difference that the researchers replaced the object phrases by no-label attention phrases, to evaluate the impact of unrelated speech on looking preferences. The results showed that there was a preference for looking at the familiar picture over the novel picture during baseline. This suggested that monolingual children were stronger than bilingual children in their use of disambiguation, while trilingual children did not show disambiguation.

In summary, altogether these results show that exposure to two languages has an effect on children's vocabulary size (see Hoff & Elledge, 2005; Hoff et al., 2010; Vagh et al., 2009), although the delay can be less visible when taking into account the total vocabulary in both languages (see Byers-Heinlein & Werker, 2009; Hammer et al, 2009; Pearson et al., 1993). In addition, the overall tendency seems to be for receptive vocabulary to be relatively more spared than expressive vocabulary (see Rescorla & Achenbach, 2002; Yan & Nicoladis, 2009). In this thesis we will carefully measure bilingual vocabulary in production and comprehension, in the two languages when possible, and use standardised tests as well as parental questionnaires, to obtain a robust picture of children's lexicon size.

Semantic-Lexical Organisation in Bilingual and Monolingual Children

We have seen in the previous section that the development of language and especially vocabulary – as measured by vocabulary size – does not always follow the same paths in bilinguals as compared to monolinguals. Here we will examine the internal lexical organisation of young bilinguals and compare it to that of monolinguals. Do early bilinguals possess two distinct lexicons for each of their languages or do they have one integrated system for both L1 and L2 (Genesee, Nicoladis & Paradis, 1995)? Are words semantically related, within and across languages? To answer these questions we need first to examine the studies which have looked into the lexical organisation in bilingual adults and children (first section), and then discuss the research on semantic-lexical organisation in monolingual children, as, to our knowledge, there is very little available data on semantic-lexical organisation in young bilinguals.

1- Semantic-Lexical Organisation in Bilingual Adults and Children

Over the past twenty years much knowledge has been acquired in the field of bilingual word processing in adults (e.g., Schoonbaert et al., 2009). This is an important field of research for two reasons: first, it offers the necessary knowledge about how bilinguals control two separate communication systems, while being at the same time able to translate from one system to the other; second, it helps to increase the knowledge of word representation and processing (Schwanenflugel & Rey, 1986; Sheng, McGregor & Marian, 2006). One of the key issues that researchers face in the bilingual area is working out whether bilingual word processors code the information of languages in two language-specific memory systems, or merge them into a common language-independent store (De Groot & Nas, 1991). The Revised Hierarchical model (Kroll & Stewart, 1994) and the Bilingual Interactive Activation (Dijsktra & Van Heuven, 2002) are the two most important models proposed to describe the bilingual lexicons in adults. These models both posit non-selective access to words, that is, a word will activate candidates in the two languages, and the two lexicons are linked to a shared conceptual system that includes the meaning of the words (Grainger et al., 2010). In the RHM, it is assumed that the translation equivalents in the diverse lexicons are linked by excitatory connections (Brysbaert & Duyck, 2010), that is, the word 'dog' would activate its translator equivalent 'chien' in a French-English bilingual. At the beginning of second language acquisition, the direction of activation from L2 to L1 (backward priming) is stronger than from L1 to L2 (forward priming). In addition, the links between concepts and L1 words are stronger than the connections between L2 words and concepts (Brysbaert & Duyck, 2010; Grainger et al., 2010). The RHM model was introduced to account for the data showing

unequal translation achievement by late bilinguals who learn L2 when L1 had been mastered (Brysbaert & Duyck, 2010; Kroll et al, 2010).

The second, BIA model is aimed at balanced bilinguals, for whom words from the two languages are fully integrated in the lexicon (Van Heuven, Dijkstra & Grainger, 1998). In this approach, a layer of language nodes is proposed as the mechanism to perform language selection (Kroll & Tokowicz, 2005).

Both models are difficult to apply to children as they cannot be classified easily as balanced or unbalanced bilinguals, due to their very short time of exposure all together, and to the immaturity of their language processing system.

In the adult literature the semantic priming paradigm is a tool that has been commonly employed to examine the nature of lexical representation. In this paradigm, two words are presented in short succession, and a decision is required on the second word, for example a lexical decision (decide whether it is a real word or not). In a semantic priming condition, the two words, the prime and the target, would be semantically related, e.g., 'apple' and 'banana'. In an unrelated, control condition the two words would not share any similarity, such as 'dog' and 'banana'. The idea is that 'apple' will automatically spread activation to another semantically related word such as 'banana', resulting in faster reaction times for 'banana' when preceded by 'apple' than 'dog' (Hutchinson, 2003; Neely, 1976; Savage, Lieven, Theakston & Tomasello, 2006). Recently Arias-Trejo and Plunkett (2009, 2011; see also Styles & Plunkett, 2009, 2011) have successfully adapted this paradigm for those in early childhood, using looking times rather than reaction times to assess lexical activation. In the following section we will review the few known studies having examined lexical representations in bilingual children, before describing in detail the pioneering work conducted by Plunkett and colleagues.

Pearson et al. (1995) examined the view that bilingual children integrate information from two languages in one single system. Twenty-seven bilingual infants (English, Spanish) aged 8 months to 2 years and 6 months, participated in this study. Eighteen of them were observed 2 to 10 times while 9 infants were seen only once. The MacArthur CDI and its Spanish adaptation were used for collecting the vocabulary data, so that parents filled in both CDIs during the same week. The researchers focused on the number of translation pairs which were equal. The results revealed that the proportion of lexical overlap between the two languages was not significant, which does not support the hypothesis that bilinguals process linguistic information into one unique lexical system (also see Pearson et al., 1993).

Another example that provides further evidence that bilingual children represent languages in dual lexical systems comes from Holowka, Brosseau-Lapré and Petitto (2002) who investigated how children, simultaneously exposed to two languages, organise the vocabulary meanings across their two languages. Six children were videotaped seven times (one hour each time) over 12 months. The ages of the children ranged from 7 months to 26 months. Three bilingual children acquired French and English, and the other children acquired French and LSQ (French Canadian Sign Language). The researchers asked parents to use the language which they usually used with the infant throughout the task. Two experimenters (native speakers in each language) also participated in the play sessions. The procedure was as follows: parents were first asked to take part in an online videotaped interview about their child's language development. Then the infant played and connected with both the parents and the experimenters, after which they interacted with one parent at a time and finally with one experimenter at a

time. After each session parents filled out, when relevant, a questionnaire about the child's knowledge of LSQ (Charron & Petitto, 2009), the CDI in English (Fenson et al., 1991) as well as its translation and adaptation in French (Trudeau, Frank & Poulin-Dubois, 1997). The results suggested that not only were there no differences between bilinguals and monolinguals in terms of the time taken to acquire each language, but they also offered comparable translations in their first lexicons. These findings provided evidence that bilingual children at an early age could perfectly distinguish between their two language systems, suggesting a differentiation in the child's memory system for L1 and L2.

However, another study exploring the representation of lexicons in bilingual infants has yielded results that clearly differ from the findings obtained by previous studies. Von Holzen and Mani (2012) investigated whether spoken words from the second language activate related words from the first language in 20 bilingual infants (German-English) aged between 21 and 43 months. The Oxford CDI (Hamilton, Plunkett & Schafer 2000) and its German version, the Fragebogen zur Frühkindlichen Sprachentwicklung (Frakis; Szagun, Stumper & Schramm, 2009) were used to assess vocabulary. An adaptation (Arias-Trejo & Plunkett, 2009) of the intermodal preferential looking task (IPL) was used. The experiment consisted of 24 trials grouped into two blocks. In the first block, 3 trials were made of words phonologically related between languages, for example "I saw a fire… Eier" (in these examples, the first word is the prime, the second is the target; 'Eier' in German means 'egg'), 3 trials were made of words phonologically related through translation ("I have a leg… Stein"; 'Stein' means 'stone'; 'leg' translates into 'Bein' in German, which is phonologically related to 'Stein') and 6 trials were made of unrelated words ("I bought a cloth… Hund"; 'Hund' means 'dog'). The second

block was similar to the first, but the target and distractor images which were used in phonological priming and phonological priming through translation in the first block were presented in the unrelated condition. All the prime words were presented in a carrier phrase. The prime, always in English, was followed by the target label in German after a 200ms interval. Finally images of the target and the distracter were presented side by side for 2000ms.

The results showed that infants looked longer at the target in the two phonological priming conditions (phonological priming and phonological priming through translation) than in the unrelated condition, suggesting that words presented in one language could activate related words in the other language. In other words, at the age of 21 to 43 months, bilinguals may have a lexical organisation comparable to that of bilingual adults, which supports the idea of non-selective lexical access.

A way to reconcile the results presented so far is found in Volterra and Taeschner (1978) who conducted monthly records of 30 minutes in each language (Italian/German) with their first child from 1;5 to 3;6 years old and with their second child from 1;2 to 2;6 years old. Three stages of development were identified: in the first stage, the child said sentences or words in one language and said other sentences or words in the other language in different situations. In the second stage the child responded in the same language to a question, and sometimes said the words in her two languages at the same time. Moreover she used the same grammar in both languages, for example she placed adjectives before names in German and Italian, even though it is only valid in German. In the third stage, the child correctly used the two languages, although there was an overlap but not at the syntactic level. The researchers concluded from these results

that children start by coding elements of the two languages in one single lexical system, and over time develop a lexicon for each language, but still use the same syntactic rules for two languages. Finally children reach a stage where she has two lexicons and two sets of syntactic rules.

Although the models reviewed above appear to show that bilingual adults have integrated two languages into one lexicon (Brysbaert & Duyck, 2010; Van Heuven et al., 1998), the results of other studies present arguments for and against the notion that two languages share one single lexicon system (Holowka et al., 2002; Pearson et al., 1993, 1995; Von Holzen & Mani, 2012). In addition, there is evidence that bilinguals with an early exposure to two languages store each of them separately and with time integrate both languages into one lexicon (Volterra & Taeschner, 1978). However, the majority of studies mentioned so far – with the exception of Von Holzen and Mani (2012) have studied children's production of words, which might be constrained differently than their comprehension system.

2- Semantic-Lexical Organisation in Monolingual Children

In a very recent and important study, Arias-Trejo and Plunkett (2009) sought to understand the time and the way in which a semantic system of words is developed in monolingual children, by testing word-word associations during early lexical growth. The researchers used auditory word pairs, presented in close contingency, to direct the attention of children to a target image, with an Intermodal Preferential Looking paradigm (IPL). Three experiments were conducted. In the first experiment they explored the effect of priming when a word is followed by related or unrelated targets. In this experiment, 72 words were used as stimuli: 24 words employed as prime, 24 as target and 24 as distracters. Fifty-five English 18-month-olds and fifty-six 21-month-olds were tested. Each

participant was presented with 12 trials in four conditions, totalling three trials for each condition, Prime-Target, Prime-Look, Neutral-Target and Neutral-Look (for example, 'cat'-'dog', 'cat'-'look', 'plate'-'dog' and 'plate'-'look', respectively). The 'Look' condition corresponded to a situation where the target was not named, but the word 'Look!' was presented instead. The prime was inserted in the carrier sentence, for instance "I saw a cat" followed by 200ms of silence, after which the target word was presented. 200ms after the onset of the target word, a pair of pictures was displayed for 2000ms as the target and distracter pictures. The prime word and the target image were semantically and associatively related in the priming condition, whereas the prime was not related to the target and distracter images in the neutral condition. The target picture was unlabelled in both the Prime-look and the Neutral-look conditions. Target and distracter words were phonologically similar (e.g., same number of syllables, starting with the same phoneme, e. g. 'cat' and 'cup'), and primes and targets were not semantically related with the distracter label.

The results showed that 18-month-olds looked longer at the target when it was labelled regardless of the prime condition (related, unrelated), but the 21-month-olds showed a preference for the target picture only in the related condition (that is, they failed to look longer that the named target when preceded by an unrelated prime).

The second experiment aimed to assess the overlapping and facilitating roles of exposure to related and unrelated words on the subsequent processing of words when the related condition involved a repetition of the identical label. Here thirty-nine 21-month-olds and 39 18-month-olds were tested. Each participant was presented with nine trials in three conditions, with three trials per condition e.g.

repetition prime-target (e. g., 'boot'-'boot'), prime-look ('boot'-'look') and neutral-target ('juice'-'boot'). The procedure was the same as in Experiment 1, but the targets and distracters shared no phonological onset and there was no similarity in phonological onset among prime words and target or distracters in the Neutral-target condition.

The results indicated that infants at the two ages showed a preference for the target image in the Prime-target and Neutral-target conditions, suggesting that naming the target had an effect on looking behaviour.

The third experiment aimed to assess whether hearing the target word without the preceding prime word would elicit differences in looking times. Thirty 18-month-olds and thirty 21-month-olds were tested with a procedure similar to that used in Experiments 1 and 2, except that each participant was presented with nine trials of target-distracter pairs. The trial began with the carrier phrase "Look at this", "Uh look" or "Hey Wow", followed by the target word and the target/distracter images.

The results indicated that the 18 and 21 month old infants did not differ in their looking at the target: the two groups looked longer at the target than the distracter images.

Altogether, this shows that words are semantically organised by the age of 21 months, suggesting that the lexicon's initial organisation is based on semantic principles that reflect the similarity of word meanings, even when children have a limited vocabulary. As concluded by Arias-Trejo and Plunkett (2009), "The study also showed that the human mind clusters words with similar or related meanings together in a lexical space, while pushing words with unrelated meanings apart" (p. 3644).

Styles, Arias-Trejo and Plunkett (2008) conducted a study using a wider age range of children to investigate whether semantic priming emerges in infancy. They looked at the effects of priming in preferential looking in 18, 21 and 24-month-olds over three experiments. In the first experiment seventy-two 18-month-olds and seventy-two 24-month-olds participated. Each child was presented with the prime in a carrier sentence, for example 'yesterday I saw a cat' followed by a 200ms interval and a target word (e.g., related: "dog" or unrelated: "bus"). 200ms after the onset of the target word, a pair of images were presented for 2500ms, depicting the target and distracter images. Half of the trials were made of semantically related prime-target pairs, and the other half of unrelated pairs. The results showed that there was a priming effect in 24-month-olds, as they looked longer at the target image in the related trials than in the unrelated ones. This result could have been due to a priming effect propagating from the prime to the target word and then to the target image, but it could also have been due to an activation propagating directly from the prime to the target image. In Experiment 2, the effect of naming the target was investigated in the two priming conditions (related, unrelated): half of the trials had a named target as in Exp1, and the other half did not have any named target (so only the prime sentence and the images were presented). Thirty-six participants aged 18 months and 40 participants aged 24 months were tested.

The results did not reveal any effect of priming in 18 or 24 month olds in the unnamed target condition, although the 18 month olds did look longer at the target in the named condition.

In Experiment 3, two new modifications were tested: (1) the target name was replaced by the word "Look!" in half of the trials; (2) targets and distracters shared

the same phonemic onset. Fifty-two 18-month-olds and 56 21-month-olds were tested. The results showed that the 18-month-old infants looked longer at the targets in the named condition regardless of the priming condition, and that 21-month-olds looked longer at the targets than the distracters when the target was named and the priming was related. Overall the findings suggested that lexicon connectivity emerges between 18 and 21 months of age.

Styles et al. (2008) reported that there was no priming effect in 18-month-olds. This may in fact be due to the need for an increase in time interval between the prime to the target to reach activation for younger children. In order to examine the impact of stimulus onset asynchrony (SOA), Styles and Plunkett (2009) conducted another experiment adding another condition, so that the time interval between the auditory stimulus and target, distracter images were either 200ms or 400ms. Again, half of the trials were made of semantically related prime-target words or unrelated pairs. Twelve trials were presented for each participant.

Results showed that the target word was recognised by both ages, as reflected by longer looking times towards the named picture as compared to the unnamed one. Most importantly, the target picture was attended to for longer in related trials than in unrelated trials, but this was true only for the 24-month-olds.

Together, the results suggested that acquired words are integrated into a complex system by children, using the same kind of semantic relations than those found in adults. According to Styles and Plunkett (2009) the semantic organization seems to emerge at approximately 24 months of age, at least as measured by this kind of experimental procedure. So there is evidence of a semantic organisation in young children, at least from the age of 24 months.

So far, the general findings point to a semantic priming effect in infants around two years of age. However, to determine whether the effect is due to the relation between the prime and the target, or to a transfer of activation from the prime to the target picture (without a need for the target label), Styles and Plunkett (2011) conducted similar experiments but without the target label. Thirty-six 18-month-olds and 24-month-olds were tested. Two stimulus lists were created, half of them were made of prime/targets taxonomically and associatively related, the other half was made of unrelated pairs. Each prime was presented with two different target pictures (related, unrelated). The prime and target had no phonological, semantic or associative relation with the distracter. 12 words were used as the prime and 12 were used as target images which appeared alongside the 12 distracter images. Infants were presented with the prime in a carrier sentence, for example, 'Yesterday, I saw a sheep' and two pictures (target, distracter), e.g., 'cow' and `toast'. The results showed that infants in the two age groups did not show any preference for the target word, as mean looking times to the target and distracter images were equal irrespective of prime condition (related or unrelated). The findings suggested that the priming effect as found in previous studies is mediated by the relation between the spoken target and prime words.

The studies above evaluated the effect of hearing related words by using infants' looking direction and duration. The study below focuses on the effect of hearing a target word preceded by a prime image and was conducted by Mani, Durrant and Floccia (2012), who aimed at investigating whether hearing a word or seeing the corresponding picture would activate any other words related to it semantically, phonologically and phono-semantically. In the first experiment, 28 children aged 24 months were tested in a picture-priming task. Each participant was presented

with an unnamed prime image for 1.5s. At the offset of the prime picture a blank screen was presented for 200ms, followed by two pictures (target and distracter pictures) for 2.5s. 50ms after the onset of the two pictures, the target word was presented. In half of the trials there was a phonological relation between the priming image and the label for the target images (e.g., 'boat'-'bowl'). Then the target word – and image was 'cup', semantically related to 'bowl'. In the second half of the trials, no semantic, phonological or phono-semantic relations were selected between the prime and the label for the target image. In the second experiment, thirty-one 24-month-old infants were tested using the same procedure as in Experiment 1, except for a fixed attention getter used between trials. The infants were presented with eight trials. In the first half of the trials, the label target was phono-semantically related to an unnamed prime picture. However, in the other half there were no semantic, phonological or phono-semantic relations between labels of targets and priming pictures.

The results showed that the infants in both experiments looked longer to the target in the phono-semantically related condition than in the unrelated condition. These results strongly support the hypotheses that seeing objects activate other words that are phono-semantically related at 24 month olds.

Taking all of these results together, it seems clear that semantic priming between related words can be found in young children's lexicon from the age of 21 months, and it is robust enough to activate both phonological and semantic relations (Mani et al., 2012). Furthermore, the findings suggest that monolingual children integrate each word they acquire into a composite based on relationships between words, similar to an adult-like semantic system.

The study of semantic relationships between words, as we intend to follow up on in this thesis, requires that we can determine what kinds of relations are expected to be found in the lexicon. Generally, psychologists define semantic relations along two axes: thematic or taxonomic.

Schematic or so-called thematic relations are determined as relatedness between objects faced together in the one context, for example railways, trains, platforms, stations, engineers. Therefore, there are spatial and/or temporal common relatedness, and sometimes functional, relationships between these words (Perraudin & Mounoud, 2009). In other words, thematic relations consist of external or complementary relationships among things or actions, and other things that co-occur or interact in the same place and time (Lin & Murphy, 2001). In contrast, information organisation of taxonomies allows people to process knowledge in a more advanced and economical way. Components of a specific category, e.g., dog and wolf, share all features of the category 'dogs' in conjunction with some additional differentiating features (Miller & Eilam, 2008). Taxonomic concepts are considered important for the advanced learning of quantitative and qualitative concepts (Sung, Chang & Lee, 2008).

Traditionally it was assumed that during development, a shift from thematic relations to taxonomic relations is observed. In other words, young children are found to show a preference for thematic rather than taxonomic relations (Greenfield &Scott, 1986; Smiley & Brown, 1979; Sung et al., 2008) but many follow-up studies have found no evidence for such shift (Bauer & Mandler, 1989; Berger & Aguerra, 2010; Borghi & Caramelli, 2003; Hashimoto, McGregor & Graham, 2007; Waxman & Namy, 1997). From these studies, it seems well established that from the age of 4, taxonomic and thematic relations are processed

similarly, but what is less clear is what happens before that age, and especially, what to expect in children aged 2 to 3 years of age.

Hypotheses

In this thesis we used the Intermodal Preferential Looking (IPL) technique to examine lexical-semantic priming in 18 and 30 month old bilingual and monolingual infants in a series of six experiments. In experiment 1, we attempted to replicate the results of Styles and Plunkett (2009) who revealed that monolingual 24-month-olds are sensitive to the semantic relation between familiar words. Here we tested older children (30 months old) for three reasons: (1) to provide a benchmark for further studies looking at bilinguals, for whom we expected a smaller vocabulary in English (we anticipated that the lexicon of a 30-month-old bilingual would be the equivalent of that of a 24-month-old monolingual); (2) to explore the relationship between vocabulary size (production, comprehension) and semantic priming effect in a monolingual population with a larger vocabulary, and therefore, with more potential for such links to be observed, and (3) to validate our adaptation of the Styles and Plunkett's technique in our lab.

In experiment 2, we examined the role of the named target in the elicitation of a priming response for the target object, again in 30 month old monolingual infants. This design was also used by Styles and Plunkett (2009) in younger children and they showed that priming could not be observed if the target was not named after the presentation of the auditory prime, suggesting that the named target was necessary to mediate the priming effect. Given that our tested population had a substantially larger vocabulary than the children tested by Styles and Plunkett, we were interested in testing whether such cross-modal priming (auditory prime – visual object) could be obtained at this stage. Again we also investigated

correlation between semantic priming effect and vocabulary size (production and comprehension).

Having established the robustness of the method in monolinguals, in Experiment 3 we tested 30 month old bilingual infants (Arabic-English) to explore whether similar results of Exp 1 would be revealed in each of their languages. Specifically, infants heard a target word preceded by a related or unrelated semantic prime in English and, in the second session, Arabic. We were interested in (1) the possible asymmetry between priming effects in each language, as a function of vocabulary size and amount of exposure, and (2) the comparison between priming effects in monolinguals and bilinguals at the same age, given that bilinguals are expected to have smaller lexicons and therefore potentially less mature semantic structure.

In experiment 4, we examined 18 month old bilingual infants in a cross-language priming study. This change in age range was justified by a study by Delle Luche et al. (submitted) showing evidence of semantic relationships in the lexicon at that age, using an all-auditory head turning paradigm, although studies by Arias-Trejo and Plunkett (2009) and Styles and Plunkett (2009) had failed to show semantic priming in monolingual 18-month-olds. We hypothesised that, across languages, the semantic connections between words would be stronger than within languages, due to the double-labelling of each concept in bilinguals. Therefore we supposed that we would be able to find some priming effect in bilingual 18-month-olds. We also looked at the symmetry between forward (L1 to L2) and backward (L2 to L1) priming as a function of amount of exposure to each language, as it is usually found that backward priming is stronger than forward priming in adult bilinguals. If the exposure measure relates to proficiency in L2, then we could expect more priming

in the backward condition than the forward condition. Again, we examined the relation between vocabulary size and semantic priming effect.

In Experiment 5, we ran a simple priming study in monolingual 18-month-olds to re-evaluate the claim that no priming could be found at this age, and most importantly, to set up a benchmark to the next experiment.

Finally, in Experiment 6 we hypothesized that if the bilingual lexicon was more interconnected than the monolingual lexicon, we could obtain a semantic priming effect within language in 18 month old bilingual children.

Chapter three

Experiment 1: Semantic/Lexical Priming in 30 month old Monolingual Infants

In this first study, the primary aim was to replicate the main results from Styles and Plunkett (2009) who showed that there was lexical/semantic priming in monolingual infants aged 24 months. In terms of stimuli and procedure, this was done to establish a baseline for the next experiments. In addition, by testing a group of children older than those tested by Styles and Plunkett, and who had necessarily a larger lexicon, we expected to be in a better position to examine the impact of size of vocabulary on priming effects. This analysis would be important in the forthcoming bilingual experiments. Accordingly, we tested a large number of participants to increase the power of the correlational analyses between the size of vocabulary and priming effects.

Originally, another aim was to examine the potential priming differences between taxonomic and thematic relationships since previous studies (e.g., Inhelder & Piaget, 1964; Markman & Hutchinson, 1984) had established that young children tended to be more sensitive to thematic than taxonomic relationships. However, on the early lexicon, constraints were such that it turned out to be difficult to construct a balanced set of stimuli regarding this factor. In addition, Arias-Trejo and Plunkett's (2013) recent study suggested that, at the age of 24 months, priming was obtained equally with taxonomically and associatively related primes. This suggested that this factor would not have modulated the results reported in Exp.1.

In summary, Exp. 1 was a priming experiment with 30-month-old monolingual infants, in which we evaluated visual preferences/gaze direction when the child heard a pair of semantically related or unrelated words, and in which we examined the links between priming and size of vocabulary.

Method

Participants

Children came from the Plymouth Babylab database (to which parents registered voluntarily).

A total of 53 participants aged 30 month (29 boys, 24 girls) took part in this experiment. They were all English-learning monolingual infants with an average age of 29.4 months (range from 27.8 to 29.4 months). All children were reported by their parents as having normal hearing, no development delay, and the children were no more than 6 weeks premature. These criteria were the same for all experiments and, therefore, we do not repeat them hereafter. The infants were awarded a t-shirt or £4 for transport expenses, plus a 'Baby Scientist' certificate. An additional three children were excluded for the following reasons: one child had a speech problem; one child was trilingual; and one child had a hearing problem.

Vocabulary Estimates and Demographic Data

Vocabulary was estimated through a parental questionnaire (the Oxford CDI or OCDI, Hamilton et al., 2000), which contained 416 words which parents indicated as being either understood simply or used actually by their child at the moment of testing. Not only to complement this widely used measure, but, also because our

population was slightly beyond the OCDI's upper age limit (28 months), we also used two face-to-face-interaction-based scales to assess vocabulary comprehension (BPVS III) and production (a British English adaptation of the German SETK, see Cattani et al., submitted).

The British Picture Vocabulary Scale III (Dunn, Dunn & NFER, 2009)

The BPVS III is a receptive vocabulary test for Standard British English between 36 months and 16 years 11 months. Each item consists of four colour illustrations on a plate and the children's task is to select the picture which illustrates the meaning of a word said by the test administrator. The test starts on the first item and ends at the ceiling set which is established when, within a subset, a child makes eight or more consecutive errors. The scores are calculated as the number of correct responses.

Object Naming Sub-test (adapted English SETK-2)

The language test Sprachentwicklungstest-2 (SETK-2, Grimm, 2000) was designed originally in Germany to measure, in 24 to 36 month-old German children, receptive and expressive language skills. We divided this test into four sub-tests of which we used only the object naming sub-test. This object-naming test consisted of 30 items of which the first six were actual objects. The latter were matched to the original items in the German version. The remaining 24 items were colour pictures which were photocopied from the German test, with the exception of the item 'petrol station' which was replaced since it did not look like an English petrol station. For each item, the children were asked 'What's this?' and were given a score of 1 if the child offered any of the English words given as options for that

item (Appendix A). If the child gave a response which was not on the list (e.g., 'egg' for ball or 'apple' for 'pear') or in the other language, this was scored as 0.

We also asked parents to provide us with details regarding the child's place of birth; the highest qualification of the mother and father with their current occupations; the length of time living in the UK; and the presence and number of younger or older siblings. These pieces of data were used in the Language Exposure Questionnaire (LEQ), developed by Cattani et al. (submitted), which we used mainly in the following experiments to evaluate the amount of exposure to each language.

Stimuli

In this study, 72 words were selected from the Oxford CDI, such that (based on the data from 28-month-olds in the Oxford CDI database) the majority of children, at the age of 30 months, could say those words or, at least, understand them. We constructed a stimulus list consisting of 24 prime words, 24 target words and 24 distracter words. For each target and distracter words, their corresponding images were selected. The prime and the target words were related semantically, e.g. 'sheep'/'cow', or non-semantically, e.g. 'boot'/ 'door'. Ten of the semantically related pairs were related taxonomically (for example 'cat' and 'dog') and 2, like 'bib' and 'baby', were related thematically. The distracter was not related to either the prime or the target word. Prime, target and distracter words were controlled for phonological onset similarity so that they all started either with a different phoneme, as 'apple', 'banana' and 'lion', or with the same phoneme, as 'bib', 'baby' and 'ball'. As a result of this condition, we had 2 trials with a similar phonological onset (priming, target and distractor) and 10 trials which differed in their phonological onset (see appendix B).

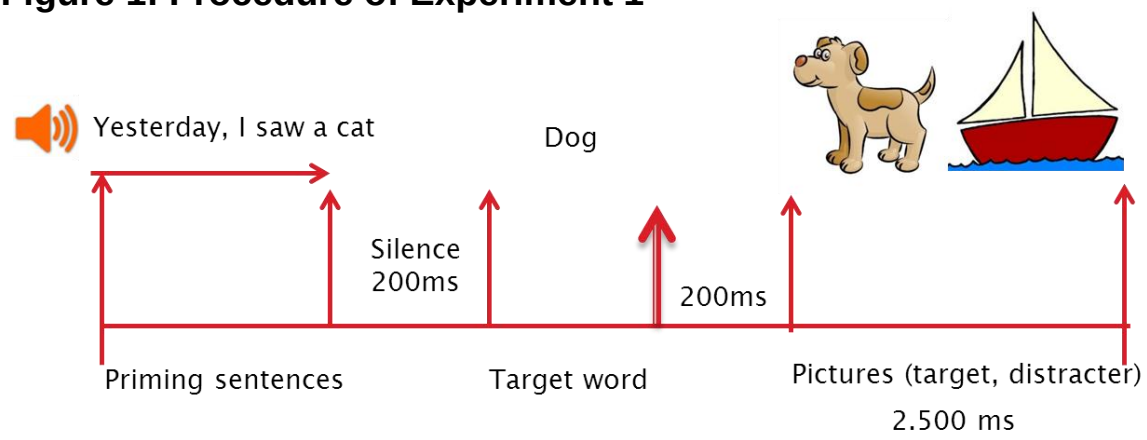
The stimuli were recorded by an English female speaker who was born and raised in the South West part of England. Primes were produced in a carrier sentence ('Yesterday I saw a sheep', see Figure 1) and targets were produced in isolation, as in Arias-Trejo and Plunkett (2009). A pair of images, depicting the target and the distracter, was chosen from colour pictures on the internet so that, according to the experimenter, they would represent adequately the corresponding objects (see appendix C for measures on the stimuli in terms of duration, pitch and intensity).

Procedure

Parents and children were met in the psychology reception area at the Plymouth Babylab and parents were offered tea or coffee. They had been asked to bring in the OCDI (sent to them by email) and on the day of the study they completed also the consent form and gave us some demographic data. In order to double check whether or not the children knew the experimental words, parents checked a list of words which were used in the experiment. The preferential looking experiment was conducted in a special room, in which two cameras were mounted above a screen and on which pictures were presented side by side via a video projector. We recorded the child's eye movements through the cameras, and sound was delivered through one loudspeaker located centrally above the two images. The child was sitting on a high seat facing a display screen at approximately 90 cm from her parents. The experimenter sat away from the display, blind to the stimuli presented, and controlled manually the presentation of each trial (presented randomly). The experimenter displayed a cartoon to attract the child's attention to the screen; the time length of the cartoon depended on the child's response and her focus on the display screen. When the child's attention was focused on the screen, the screen went blank and each trial started with the priming sentence, for

example, ‘yesterday I saw a cat’, followed by a 200 ms interval after which the target word was produced in isolation (e.g., ‘dog’). Two hundred ms after the target word ended, the two pictures, depicting the target and the appropriate distracter, were presented side by side for a total duration of 2500 ms.

Figure 1: Procedure of Experiment 1



Each child was presented with 24 trials, half of which had a semantic relationship between the prime and the target (‘Yesterday I saw a cat’, ‘dog’, followed by a picture of a dog and a boat) and the other half did not (‘Yesterday I saw an elephant’, ‘bus’, followed by a picture of a bus and pair of trousers). Each particular word was presented only once to each child. Trials were presented randomly to each child.

Results

Out of the 1272 expected responses (which corresponded to 53 times 24), 34 responses were excluded because for these trials and as reported by the parental questionnaire, the participant did not know the priming and/or target words.

For each child and each trial, we computed two dependent variables: the longest look (LLK) which compares looking at the target picture relative to the distracter

picture by computing the difference between the longest look to the target and the longest look to the distracter; and the proportion of total looking time (PTL) towards the target as compared to the total looking time towards the two pictures (target plus distracter). The 53 children's results were analysed in an ANOVA with Priming Relation as a repeated measure (prime and target unrelated versus related).

For the LLK measure, there was an effect of Priming Relation ($F(1, 52) = 41.34$, $p < .001$, $\eta^2 = .44$), due to an average LLK of 371.6ms in the related condition ($t(52) = 8.94$, $p < .0001$, t-test against 0) compared to -19.9ms in the unrelated condition ($t(52) < 1$; see Figure 2).

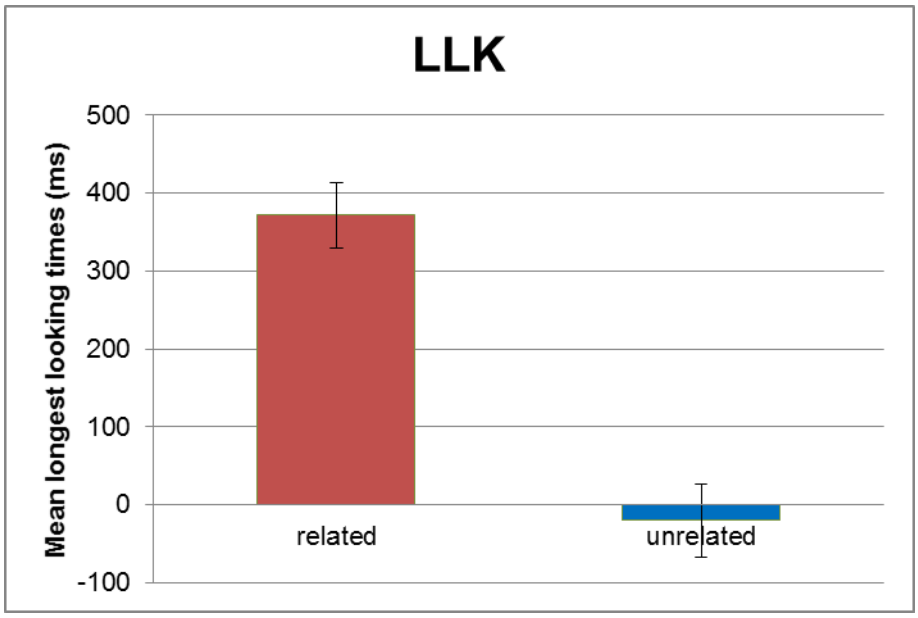


Figure 2: Difference in Mean Longest Looking Times (LLK) between Target and Distracter, as a Function of the Priming Relationship (related, unrelated)

For the proportion of looks, there was again a Priming Relationship effect ($F(1, 52) = 12.95$, $p = .001$ $\eta^2 = .199$). The average PTL was 16% in the related condition ($t(52) = 9.54$, $p < .0001$, one-sample t-test against 0), compared to 0.2% in the unrelated condition ($t(52) < 1$, see Figure 3).

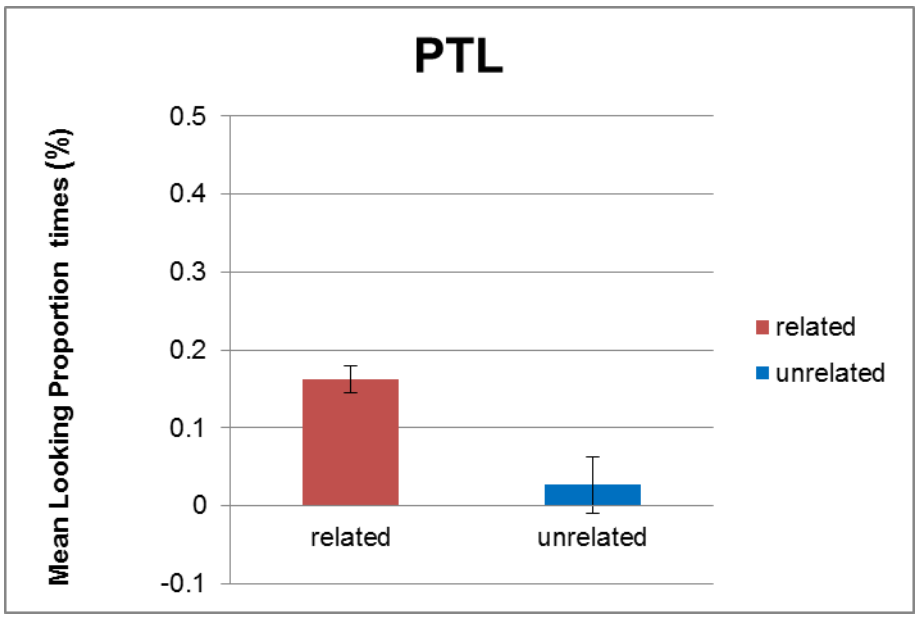


Figure 3: Mean Proportion of Looking Times (PTL) to the Target as a Function of the Priming Relation (related versus unrelated)

Vocabulary Tests

The mean comprehension OCDI score was 54 words (SD= 63) out of 416 and the mean production was 327 words (SD= 97). In SETK, the mean score was 24.2 (SD= 3.5) and children had a mean BPVS raw score of 35.7 (SD= 11.3). We will only present raw scores for these tests as for the SETK, there are no standardised tables in English yet; for the BPVS, standardised scores are only available for children 36 months and above. For each child, a "priming score" was computed as the average difference between the longest look to the target minus the longest look to the distracter in the related condition, taking away the difference between the LLK to the target minus the LLK to the distracter in the unrelated condition (same for PTL). A higher value corresponded to the child displaying more priming. The resulting mean priming score for LLK was 391.46 ms (SD=443.22) and the mean priming score for PTL was 0.14% (SD=0.3).

There was no significant correlation between the priming scores and any vocabulary measure or age (see Table 1). Furthermore, probably because the age range was very narrow, there was no correlation between age and any vocabulary measures.

However most vocabulary measures correlated with each other: BPVS and SETK ($r=.33$, $p<.05$), BPVS and OCDI production ($r=.42$, $p<.01$) and the correlation between BPVS and total OCDI was marginally significant ($r=.27$, $p=.051$). There was a significant correlation between SETK and OCDI production ($r=.37$, $p<.01$) and SETK and total OCDI ($r=.37$, $p<.01$), whereas a negative correlation was found between OCDI comprehension and OCDI production ($r=-.86$, $p<.0001$). There was, also, a negative correlation between BPVS and OCDI comprehension ($r=-.42$, $p<.01$). However, no correlation was found between SETK and OCDI comprehension ($r=-.25$).

Table 1: Correlations between Priming Scores (LLK, PTL); Vocabulary Measures; and Age

	Priming LLK		Priming PTL		Age	
	R	sig	R	sig	R	sig
Age	-.15	.27	.15	.28		
BPVS	-.11	.44	-.05	.72	.002	.99
SETK	-.09	.23	-.06	.67	-.03	.83
OCDI comprehension	-.09	.52	-.21	.13	.04	.76
OCDI production	.03	.86	.09	.51	-.08	.55
OCDI cumulate	-.06	.66	-.09	.55	-.1	.47

Discussion of Experiment 1

In an extension of Styles and Plunkett's (2009) study of 24 month old infants, Exp1 aimed mainly to examine whether or not hearing a word activated a semantically

related spoken target word in 30 month old infants. In order to address this issue, we used an adaptation of the Intermodal Preferential Looking (IPL) task in which infants were presented with related and unrelated pairs of words, such as the target 'dog' preceded by the related prime 'cat' or the unrelated prime 'apple'. Furthermore, we examined whether or not there was any correlation between the priming score and vocabulary measures.

The results of Exp. 1 demonstrated that children at 30 months of age showed a strong preference for the target image over the distracter image. However, in line with Styles and Plunkett's findings (2009), this was only when the prime and the target were related semantically. However, we failed to find any correlation between priming scores and vocabulary measures. This could be due to at least three factors. Firstly, it might be due to the fact that, originally, the BPVS vocabulary test used in this study measured achievements in children aged 3 years and older. In contrast, the Oxford CDI parental questionnaire reached a ceiling for children older than 28 months. Therefore, neither of these tools may have been entirely suitable for evaluating the size of vocabulary at 30 months in bilinguals who are expected to be slightly delayed. However, this possibility was unlikely given that all the chosen tests correlated very well with each other, showing their validity in measuring similar abilities.

A second possibility might be that the age range of our sample was too narrow to allow for modulation in terms of size of vocabulary which could relate reliably to priming scores. This was backed up by the finding that no correlation was found between age and vocabulary estimates.

Finally, it might be possible that our results were in line with numerous studies (Floccia, Nazzi, Austin, Arreckx & Goslin, 2011; Havy & Nazzi, 2009; Killing &

Bishop, 2008; Nazzi, 2005; Nazzi & New, 2007; Swingley, 2003; Werker, Fennell, Corcoran & Stager, 2002) which failed to link vocabulary size and infants' use of phonological information in lexical tasks with infants aged 1.5 and beyond (see Swingley, 2009,) for children aged 1.2 to 1;10 ; see also the lack of a correlation in a picture-fixation task at 1.6, (Swingley & Aslin, 2007), and in a preferential looking task at 1.4 to 1.8 (Tan & Schafer, 2005). Havy and Nazzi (2009) commented that, when such a correlation was found, it was reported for younger children (1.0 in Mani & Plunkett, 2010; 1.2 in Werker et al., 2002 and in Yoshida, Fennell, Swingley & Werker, 2009), as if the effect of the size of vocabulary on the use of phonological information in lexical processing was temporary. Our task did not rely on the use of phonological information per se; however, it required still phonological analysis in the course of lexical access.

The results of Exp. 1 showed a robust priming effect in monolingual 30 month old infants. Our interpretation and that of Styles and Plunkett (2009) was that the prime word had pre-activated the target word, resulting in longer looks to the target picture. However, another interpretation (see also Styles & Plunkett, 2009) was that the longer looks at the target pictures were not due to the target word per se, but to priming spreading directly from the spoken prime to the target image, without necessarily transiting through the target word (in essence, this would be cross-modal priming). In other words, the prime in 'Yesterday I saw a cat' might activate directly semantically related concepts such as 'dog', leading to longer looks at the dog picture. In favour of this possibility was the finding – similar to Styles and Plunkett (2009) - that no naming effect was found in unrelated trials. Namely, upon hearing a prime word, children failed to look longer at the object associated with the subsequent unrelated target word.

Therefore, in Experiment 2 we tested whether or not similar results-would be observed in 30 month old monolingual children when they heard the prime words without any target words. We noted that Styles and Plunkett (2011) had run a similar experiment with 18 and 24 month-olds and that they had found no evidence of priming in that condition. Because our children were 6 months older and given that evidence of priming was much more robust in our experiment than in Styles and Plunkett's study, it was thought that, potentially, evidence of cross-modal priming could be found in these older children.

Experiment 2: Lexical/Semantic Priming in Monolingual 30-months-old Infants: Priming without an Auditory Target

In this experiment, the stimuli and procedure were similar to those used in Exp.1, the only difference was that the auditory target was not presented. If the presentation of the auditory prime was sufficient to generate activation of associated concepts in the visual modality, then a priming effect ought to be observed here.

Again, by using the same tools as in Exp. 1, we examined the effect of the size of vocabulary on priming effects.

Method

Participants:

52 children aged 30 month (27 boys, 25 girls) were recruited from the Plymouth Babylab database with an average age of 29.7 months (range 27-33 months). Participants were monolingual native English speakers and all participants were normal hearing.

Estimates of Vocabulary

As in Exp. 1, the BPVS III, the SETK and the OCDI were used to estimate vocabulary development. Demographic data was collected through a parental questionnaire.

Stimuli

We used the same stimuli as in Exp. 1; however, the target words were removed.

Procedure

The procedure used was the same as for Exp. 1, with the exception that the target words were removed. Instead, a silence corresponding to the duration of the missing target word, was introduced. Each participant was presented with the priming sentence, for example, 'Yesterday I saw an apple' and, then, two pictures depicting the target and the appropriate distracter were presented side by side, for example, 'banana' (related) and 'lion' (unrelated) for a duration of 2500ms.

Results

Out of the 1248 expected responses (which corresponded to 52 times 24), 31 responses were excluded because for these trials words (prime or target) were not known by the participants.

Repeated measure ANOVAs were performed firstly with each of the LLK or PTL dependent variables, and Priming Relation (related or unrelated prime/target) as a within-participant variable.

For the longest look measure, LLK, there was no significant effect of Priming Relation ($F(1, 51) = 1.28$, $\eta^2 = .025$). The average LLK was 139.15ms in the related condition ($t(51) = 2.1$, $p = .04$) and 67.61ms in the unrelated condition ($t(51) = 1.4$, $p = .17$, see Figure 4).

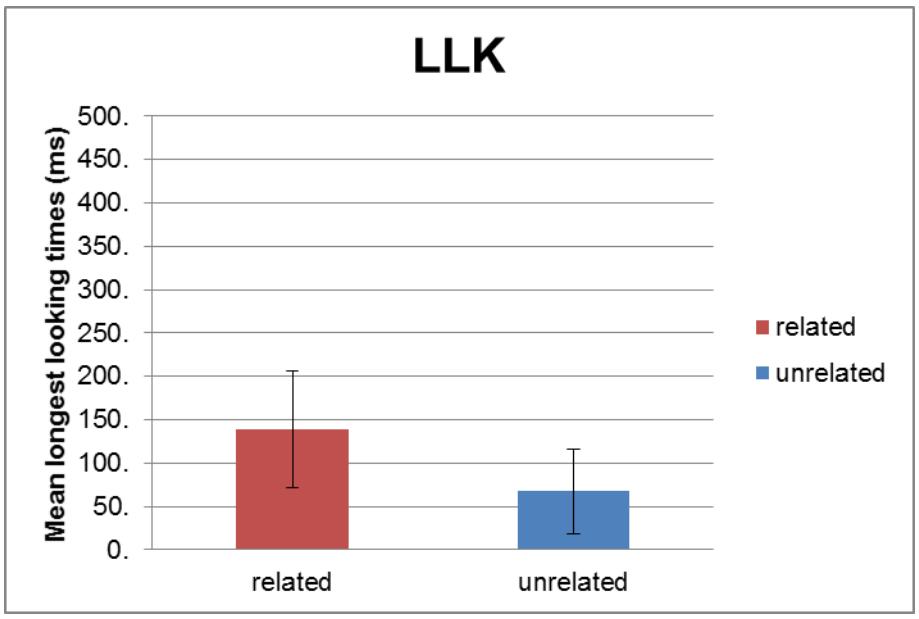


Figure 4: Mean Longest Looking Times (LLK) as a Function of Priming Relation (related versus unrelated prime)

For the PTL measure, the main effect of Priming Relation was not significant either ($F(1, 51) = 1.47$, $\eta^2 = .028$). The average PTL was .06 % in the related condition ($t(51) = 2.72$, $p = .01$) and .03 % in the unrelated condition ($t(51) = 1.49$, see Figure 5).

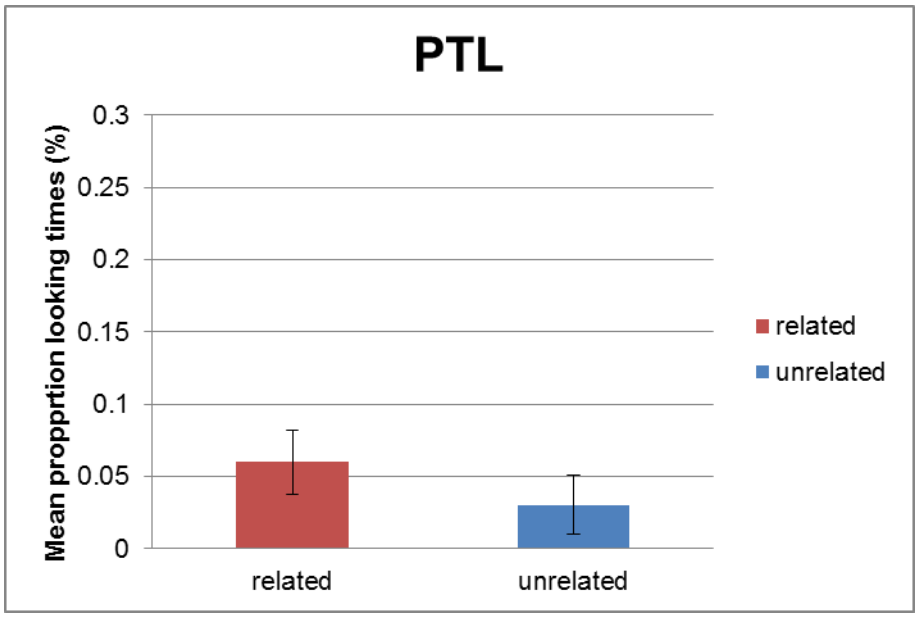


Figure 5: Mean PTL Times as a Function of Priming Relation (related versus unrelated)

Vocabulary Tests

Regarding the OCDI data, the mean comprehension OCDI score was 113 words (SD= 81; these do not include the words that children can say) out of 416 and the mean CDI production was 258 words (SD=84). The SETK score was 23.25 words (SD= 6.1), and the mean BPVS raw score was 34.13 (SD=12.6).

As in Exp. 1, a priming score was computed for each child and each dependent variable (LLK and PLT). The mean priming score for LLK was 83.4 ms (SD=459.58) and the mean priming score for PTL was .04 % (SD=.2). As shown in Table 2, no correlation was found between the Priming scores (LLK and PLT) and any vocabulary measure. As in Exp. 1, most vocabulary measures correlated with each other: BPVS and SETK ($r=.582$, $p<.0001$), BPVS and OCDI production ($r=.361$, $p<0.01$) BPVS and total OCDI ($r=.278$, $p<.05$), SETK and OCDI production ($r=-.342$, $p<.05$), and SETK and total OCDI ($r=-.297$, $p<.05$). No correlation was found between age and vocabulary measures (see Table 2).

Table 2: Correlations between Priming Scores (LLK and PTL) and Vocabulary Measures

	Priming LLK		Priming PTL		Age	
	r	Sig	r	sig	R	sig
Age	-.21	.39	-.03	.85		
BPVS	.1	.48	-.17	.21	.05	.71
SETK	-.03	.84	-.04	.79	-.06	.66
OCDI comprehension	.15	.29	.11	.42	-.06	.67

OCDI production	-.16	.26	-.09	.52	.14	.31
OCDI cumulate	-.03	.95	.03	.84	.14	.32

Discussion of Experiment 2

In Exp.1, we found a strong priming effect with 30 month old monolingual infants. Specifically, the infants preferred to look at the target more than at the distracter images when the auditory target was preceded by a semantically related prime. In order to determine whether the effect was due to the mere presentation of the prime, without transiting through the related target, we investigated whether priming words could activate target images (word-picture) when the participants were presented with a priming word but with no target label. For example, the prime-carrier sentence 'Yesterday I saw a cat' was followed by a short silent interval and, then, two pictures were presented: the target and a distracter e.g., a dog and a boat. The results of this experiment with no auditory target indicated that there was no effect of priming altogether and that the infants did not show more interest in the target images as compared to the distracter images when they were preceded by semantically related primes. Overall, participants looked slightly longer at the target than at the distracter images irrespective of priming condition (related, unrelated). This could have been due simply to a familiarity effect with target images over distracter ones. These results were in line with the results of Styles and Plunkett (2011) who did not find a priming effect in the absence of auditory target in children of 18 and 24 months of age. Perhaps, the interpretation of this result is that hearing a word might activate semantically close words but the activation might decay rapidly or be too weak to result in a robust preference for the target image. In contrast, when an auditory target is

presented after the prime, it might be sufficient to consolidate the activation of prime-related words and/or the selection of one unique candidate and, thus, result in a priming effect.

Another interpretation provided by Arias-Trejo and Plunkett (2013) is that the related prime does not activate the target itself but that the unrelated prime *inhibits* the target. In favour of this interpretation is the finding that, common to Styles and Plunkett (2009) and this study (Exp.1), there was no naming effect in unrelated trials. Namely, when children heard 'Yesterday I saw an elephant', 'bus', they did not look longer at the picture of the bus, as if the unrelated prime was masking the activation of the target word. We shall return to this interpretation later.

Having established the possibility of obtaining semantic/priming in 30 month old monolingual children with a paradigm similar to that used in Styles and Plunkett (2009), and having identified reliable tools to estimate the children's vocabulary, we examined in Exp. 3 whether comparable results could be obtained in a group of 30-month-olds raised bilingually in British English and Arabic. Given that bilingual children were found repeatedly to exhibit a smaller vocabulary in each of their languages (e.g., Hoff & Elledge, 2005), it was possible that semantic/lexical priming would also be delayed as a result of less connectivity in their smaller lexicon. On the other hand, bilingual children might be forced into connectivity by the very existence of double labelling for words. This might translate into an even more robust priming effect in each of their languages.

Experiment 3: Lexical/Semantic Priming in Arabic/English 30-month-old Infants

In Exp. 3, Arabic-English children were tested successively (one week apart) in the English and the Arabic versions of the task used in Exp.1. We obtained estimates of vocabulary by using similar tools as previously, with Arabic adaptations (being carried out by the author when necessary). In addition, a parental questionnaire, developed in Plymouth (see Cattani et al., submitted) allowed us to estimate carefully the amount of exposure to each language since it was established that the vocabulary size in bilinguals was correlated reliably to this measure (Pearson, Fernandez, Lewedeg & Oller, 1997).

Methods

Participants

The researcher recruited twenty children aged 30 month (12 boys, 8 girls) from Arabic families living in the Plymouth area; they originated from Libya (2), Egypt (2), Sudan (1), Saudi Arabia (3), United Arab Emirates (1), Iraq (6), Morocco (1), Algeria (1), Palestine (1), Kuwait (1) and Syria (1).

The final results were based on 18 children with an average age of 30.6 months (range 28.8-32.0 months); the data from two children had to be excluded because of a very low exposure to English for one of them and the other child not responding. All parents were Arabic native speakers except two mothers who were English native speakers.

Estimates of Vocabulary, Language Exposure Questionnaire (LEQ) and Demographic Data

As in the previous experiment, we used some tools to estimate vocabulary data: the BPVS III, the OCDI and the SETK. We also used an Arabic adaptation of the

OCDI (Dashash, Safi & Basaffar, 2006), and the researcher translated and adapted the BPVS III and the SETK into Arabic. Each child's vocabulary was estimated individually due to different Arabic dialects. The SETK was certainly the most reliable tool in this experiment because we asked infants to say the name of a picture or an object and we recorded his/her response as correct based on the dialect which they used. However, this did not work the same with the BPVS as the experimenter asked the infant to point to the one picture from four pictures and, in this case, he used the classic Arabic language, in which it was possible that some words were not used often at home. The same criticism could be formulated regarding the IPL procedure and the CDI, since we did not know whether parents used classic Arabic or their dialect to complete it.

In order to estimate the amount of exposure to each language, we used the Language Exposure Questionnaire (LEQ) developed in the Plymouth Babylab. It was designed to obtain an objective estimate of the average proportion of the time a child heard English and the Additional Language during a typical week (see Appendix A). Section A identified the number of language(s) spoken at home and, accordingly, directed to subsection B or C which are similar with the exception of the initial question. Section B assessed bilingual children whose parents both spoke another language at home (e.g., mother and father both spoke Arabic). Section C was completed by the families in which one parent spoke English and the other parent spoke an Additional Language to the child. These sections asked questions about the average number of hours per week a child spent in an English speaking childcare environment (nursery, day care, preschool, child-minder, relative or friend) and the number of hours per 24 hours in which the child spent sleeping. Other questions asked how often the mother and the father talked to the

child in English as opposed to the Additional Language when on their own through a range of five choices (e.g., always, usually, half the time); who spoke more to the child when the two carers were together; and the number of hours per week that a child spent time with each parent alone. Based on this information, calculations (Appendix A) estimated the number of English-hearing hours per week. Scale responses (e.g., whether the mother spoke English to the child always, most of the time, half/half, rarely or never) were converted into weights (here, 100, 75, 50, 25 and 0%); these were used to recalculate the number of English hours. For example, if the mother spent 10 hours a week on her own with her child and spoke to her mostly in English, then these ten hours would become 7.5 hours of English and 2.5 hours of the Additional Language.

Section D collected demographic data (see Exp.1).

Stimuli

For the English version of the experiment, we used the same stimuli as used in the previous experiments. For the Arabic version, the researcher translated the carrier sentences and the prime/target/distracter words into classical Arabic. Some words were changed because, in terms of similarities in their phonological onsets, they were inconsistent with the experimental conditions when they were translated from English to Arabic, in that they were either not common or they had more than one meaning (see Table 3). The stimuli were recorded by Arabic female speaker from Iraq.

Table 3: Stimuli which differ in Exp, 1 and in Exp.3 (in Arabic)

Exp 1	Exp 3	Exp 1	Exp 3
Boot	Bag	Slide	Bat

Toast	Donkey	Shirt	Dress
Penguin	Pigeon	Pig	Rabbit
Pushchair	Chair	Bowl	Fridge
Cot	Blanket	Coat	Jacket
Fork	Knife		

Procedure

Each child took part in two sessions one week apart. During the first visit, the priming experiment was delivered in English and in Arabic during the second visit. During the first visit, the BPVS III and the SETK were administered in English and in Arabic the week after. Parents were asked to complete the Language Exposure questionnaire only once in English or in Arabic; however, the OCDI was completed in English and Arabic. In order to double check whether children knew the experimental words, they also checked the list of words (in both languages) which were used in the experiment.

Results

In the English session, 67 responses were excluded from 432 responses (corresponding to 18 times 24) since the trials contained words (priming or target) which were unknown to the participant. In the Arabic section, 70 responses were excluded from the 432 total.

As in the previous experiment, repeated measure ANOVAs were carried out initially with the LLK (longest look to the target minus longest look to the distractor) and the PTL (proportion of looking time to the target as compared to target and distracter together) as dependent variables, and Priming Relation (unrelated versus related prime/target) as a within-participant variable. The

Language of the stimuli (English or Arabic) was also included as a within-participant variable.

For the LLK measure, the main effect of Priming Relation was significant (F (1, 17) = 10.45, p = .005, $\eta 2$ =.38). However, the effect of Language was not significant (F (1, 17) < 1, η^2 =.179), and neither was the interaction between Language and Priming Relation (F (1, 17) = 1.04, η^2 =.058). However, because the sessions took place on two different days, we could break down reasonably the results as two stand-alone experiments to compare priming effects in both languages. In English, the average LLK was 445.1ms in the related condition (t (17) = 4.44, p < .0001) and 278.9ms in the unrelated condition (t (17) = 2.11, p = .05); these were not different from each other (t (17) = 1.04, p = .31). Consequently, children identified the English named targets equally well in both priming conditions. In Arabic, however, the average LLK was 333.5ms (t (17) = 7.17, p < .0001) in the related condition and -32.4ms in the unrelated condition (t (17) < 1); these were different from each other (t (17) = 4.29, p < 001, see Figure 6). Children preferred looking at the Arabic targets only in the related condition.

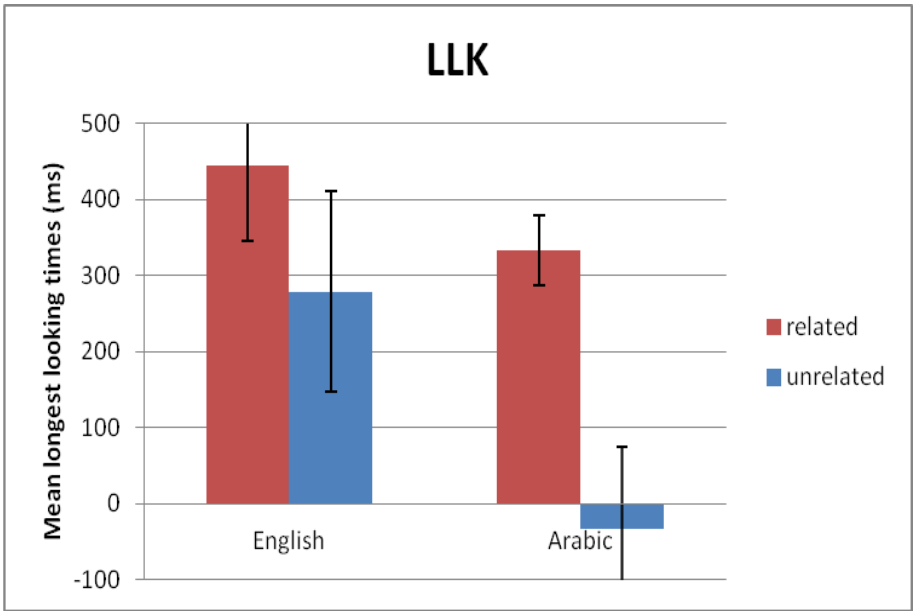


Figure 6: Mean LLK Times in Arabic and English as a Function of Priming Relation (related and unrelated)

For the proportion of looks PTL, the main effect of Priming Relation was significant (F (1, 17) = 5.09, p= .04, $\eta 2$ =.23). Again, Language had no significant effect (F (1, 17) <1, η^2 = .18) and there was no interaction between Language and Priming Relation (F (1, 17) < 1, η^2 =.008). In English, the average PTL was 17% in the related condition (t (17) = 5.35, p < .0001) and 9% in the unrelated condition (t (17) = 1.29); these were not different from each other (t (17) = 1.08). In Arabic, it was 10.2% (t (17) = 5.11, p < .0001) in the related condition and -1.7% (t (17) < 1) in the unrelated condition; these were different from each other (t (17) < 2.26, p = .037, Figure 7).

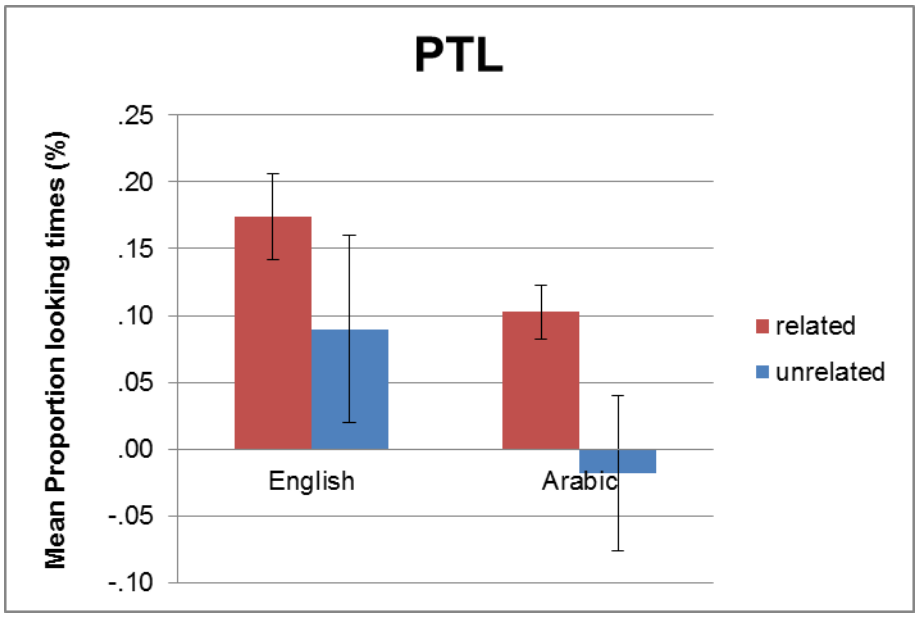


Figure 7: Mean PTL (%) in Arabic and English as a Function of Priming Relation (related versus unrelated).

Given that Language did not have any significant effect on the results, we re-ran the ANOVAs with only the Priming Relation as the independent variable (related versus unrelated).

For the LLK measure, there was a significant effect of Priming relation (F (1, 35) =8.60, p= .006, η^2 =.197). This was due to a significant recognition of the target image in the related condition (389.3ms; t (35) =7.04, p<.0001) but not in the unrelated condition (123.2ms; t (35) =1.39, see figure 8).

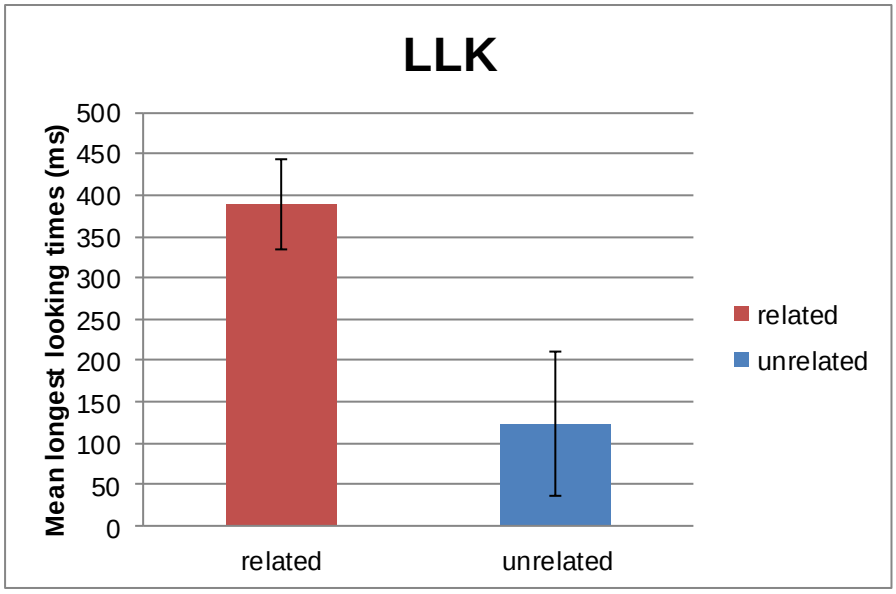


Figure 8: Mean Longest Looking Times (LLK) as a Function of Priming Relation (related versus unrelated prime), with both languages collapsed.

For the PTL measure, the main effect of Priming was again significant (F (1, 35) = 4.85, p=.034, η^2 =.122), with an average of 13.8% in the related condition and 4.6% in the unrelated condition (see Figure 9).

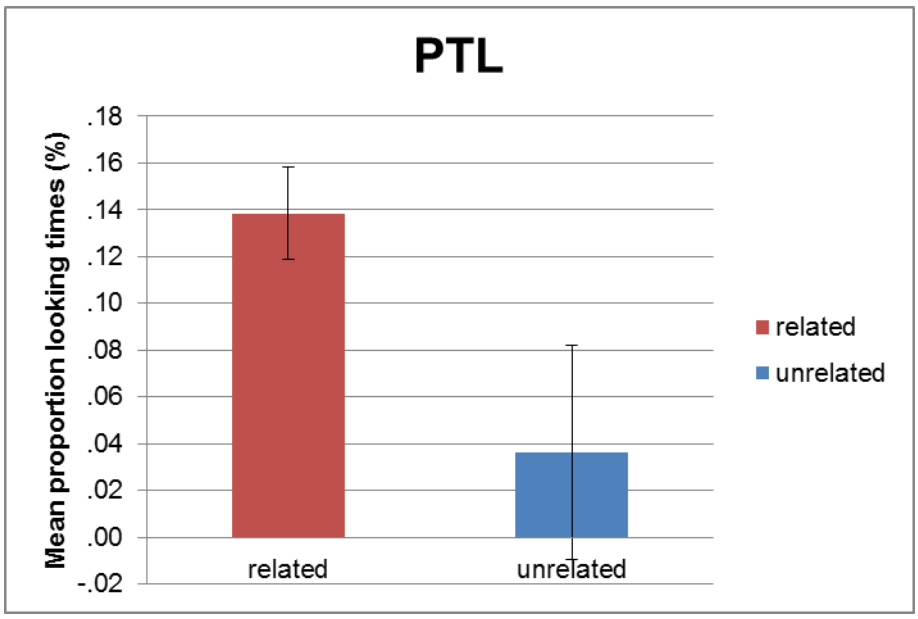


Figure 9: Mean PTL % as a Function of Priming Relation (related versus unrelated) with both languages collapsed.

Vocabulary Tests

Regarding the Arabic CDI data, the mean comprehension CDI score was 86 words out of 416 (SD= 67) and the mean CDI production was 119 words (SD=100). The Arabic SETK score was 13.8 words (SD= 6.3) and the mean raw score of the Arabic BPVS was 18.8 (SD= 7.8). Regarding the OCDI in English, the mean comprehension OCDI score was 143 words out of 416 (SD= 79) and the mean production was 96 words (SD = 54). The English SETK was 12.1 words. (SD= 8.4) and the mean raw score of the English BPVS was 19.5 (SD= 10.2).

According to the Language Exposure Questionnaire (LEQ), the mean exposure to English was 41% (SD=14%).

As in Exp. 1, for each child (and for each dependent variable) we computed a separate priming score in English and in Arabic. There was no significant correlation between the Arabic Priming score (LLK) (the mean score was 365.86 ms, SD=362.13) and the English Priming score (LLK) (mean = 166.24 ms, SD=

676.51, r=-.21). Also, there was no correlation between the Arabic Priming score PTL (mean = 0.12%, SD=0.35) and the English Priming score PTL (mean = 0.08%, SD=0.32, r=.21). Furthermore, no correlation was found between the Arabic Priming score LLK and any vocabulary measure (see Table 4). Regarding the English priming score LLK, a negative correlation, between this score and the Arabic BPVS (r=-.524, p<.05), was found. Moreover, the results indicated a marginally negative correlation between the Arabic OCDI comprehension and the English priming score LLK (r=-.424, p=.08). The more words the children knew in Arabic, the less priming effect they showed in English.

Table 4: Correlations between English and Arabic priming scores (LLK) and Vocabulary Measures

	English LLK		Arabic LLK	
	r	Sig	R	Sig
English BPVS	-.05	.83	.28	.26
English SETK	-.23	.36	-.03	.91
Comprehension OCDI	.08	.76	.01	.97
Production OCDI	-.08	.74	.25	.32
Total OCDI	.01	.96	.12	.65
LEQ	-.31	.26	.03	.92
Arabic BPVS	-.52	.03	.39	.11
Arabic SETK	-.31	.21	.29	.24
Arabic comprehension CDI	-.42	.08	.18	.47
Arabic production CDI	.09	.76	.19	.45
Arabic total CDI	-.18	.49	.26	.29

Table 5: Correlations between English and Arabic priming scores (PTL) and some Vocabulary Measures

	English PTL		Arabic PTL	
	R	sig	R	Sig

English BPVS	.06	.82	.28	.25
English SETK	-.18	.46	-.03	.91
Comprehension OCDI	.03	.92	.01	.97
Production OCDI	-.14	.57	.25	.31
Total OCDI	-.05	.86	.12	.65
LEQ	-.36	.15	-.03	.92
Arabic BPVS	-.42	.08	.01	.97
Arabic SETK	-.29	.25	-.13	.61
Arabic comprehension CDI	-.47	.05	.06	.8
Arabic production CDI	.18	.48	.18	.47
Arabic total CDI	-.12	.65	19	.45

There was also a correlation between the LEQ scores and the English SETK ($r=.64$, $p<.005$), the English OCDI comprehension ($r=.51$, $p<.05$) and the cumulated English OCDI ($r=.50$, $p<.05$). As expected, the more children were exposed to English, the more vocabulary they knew in this language. There was also a negative correlation between the LEQ score and Arabic OCDI production ($r=-.49$, $p<.05$). This showed the reverse effect: the more they were exposed to English, the fewer words they could produce in Arabic.

Most vocabulary measures correlated with each other: English BPVS and English SETK ($r=.69$, $p<.005$); English BPVS and OCDI production ($r=.52$, $p<.05$); English BPVS and total OCDI ($r=.47$, $p<.05$); English SETK and English OCDI production ($r=.504$, $p<.05$) and English SETK and total OCDI ($r=.496$, $p<.05$). There were negative correlations between the English OCDI comprehension and the Arabic SETK ($r=-.510$, $p<.05$). The more words the children understood in English, the less Arabic words they produced.

Discussion of Experiment 3

The main objective of Exp.3 was to assess whether or not, within each of their languages, bilingual children would display semantic priming between familiar words, and whether or not priming effects would be (1) comparable to those

observed in monolinguals in terms of size of effects; and (2) modulated by vocabulary sizes in each of the languages. In order to do so, we examined the effect on 30 month old bilingual infants of the semantic relationship between auditory primes and targets in two languages (Arabic, English). Overall, Exp. 3's results indicated that in the related condition bilingual infants looked longer at the target images than at the distracter images, but not in the unrelated condition, as in Exp.1.

One first way to evaluate whether or not the strength of word-to-word connections was stronger in monolingual or bilingual infants is to compare the effect sizes of priming in Exp.1 and Exp.3. The effect size found on LLK measures in Exp.1 was 0.44 and 0.197 in Exp.3; this suggested that monolingual infants had stronger semantic connections between words than their bilingual counterparts.

However, as compared to monolingual infants, bilingual infants had a smaller vocabulary in English. This could be seen clearly in our vocabulary measures. It could be that their smaller lexicon is what causes a smaller priming effect between words since semantic links grow stronger with an increasing lexicon (e.g., Hills, 2012).

Although the Arabic language was the first language for most of the participants and they averaged around 60% of exposure to Arabic, the vocabulary measures in Arabic reported an even smaller lexicon in this language as compared to English. The reason for this apparent discrepancy was most likely due to the use of classical Arabic in all the tests being adapted by the authors; this led to underestimating their dialectal knowledge. This transpired also in the looking times which (although not significantly) were higher in English than in Arabic, again due possibly to the use of classical Arabic words in the experiment.

What is more interesting in Exp.3's results is that the less words infants understood in Arabic, the more robust priming effect they showed in English. Indeed, there was a negative correlation between English priming score (LLK) and the Arabic BPVS ($r = -.524$, $p < .05$) and, less so, with the Arabic CDI comprehension ($r = -.424$, $p = .08$). This suggests that the degree of connectivity within each language-specific part of the lexicon grows not completely independently from the other one.

Another interesting result from this experiment is that, when analysing separately looking times in each language, the pattern is different in English and Arabic. In Arabic, which on average is children's most frequently encountered language, looking times are significantly longer in the related condition than in the unrelated condition, with no evidence of target recognition in the latter. In English, on the other hand, the target is recognised significantly in both priming conditions, and equally so. This is congruent with the idea that the priming effect is related to lexical size: the larger the lexicon (presumably, as seen from the LEQ, the Arabic lexicon is larger than the English one in these children) and the stronger the priming effect. When the lexicon is not developed enough (as in these children in English), then children recognise the targets but are not sufficiently sensitive to the links between words.

These findings that, in English and irrespective of the priming condition (related or unrelated), bilingual infants looked more at the target image over the distracter is also different from Styles and Plunkett's (2009) findings. They found that in the unrelated condition monolingual 24-month-olds did not look at the target image, as if the unrelated prime was masking the recognition of the target word (see also Exp.1). We could interpret this in two ways. Firstly, this could be due to bilingual

infants needing more time to recognise a word or for the activation process to develop fully and to inhibit other unrelated words. Alternatively, it could be due to bilingual infants having stronger connections between words, or less inhibitory connections (at least in one of their languages). Therefore, to distinguish between the two possibilities – slower processes or stronger activation/less inhibition – we ran a fourth study in which we examined priming across languages.

Having established the possibility of observing within-language priming in bilingual children in Exp.3, we examined cross-language priming in bilingual toddlers in Exp.4. In addition, we moved down in age by testing 18-month-olds. Although Styles and Plunkett (2009) and Arias-Trejo and Plunkett (2009) reported difficulty in showing semantic priming in 18-month-olds, Delle Luche et al. (submitted) reported evidence of word-to-word priming at this age by using a head turn procedure. Specifically, they presented infants with lists of words taken from the same semantic category (e.g., animals) versus words taken from randomly mixed categories (e.g., clothes and food items). Results showed that, as compared to the mixed categories lists, children looked longer at the single category lists. Given that we hypothesised that, overall, bilingual children might develop more word-to-word connectivity due to the quasi-systematic double-labelling of each object, this could explain why, contrary to monolingual 30-month-olds (Exp.1), bilingual 30-month-olds (Exp.3) recognised the English target in unrelated trials. We supposed that it might be possible to show semantic priming in 18-month-old bilingual infants. Using the same task as in the previous experiments, we evaluated visual preferences/gaze direction when the child heard, across languages, a pair of semantically related or unrelated words, namely, a prime in L1 (e.g., English) and a semantically related target in L2 (e.g., Arabic).

This experiment served two purposes. Firstly, it helped to understand the results of Exp.1 and Exp.3 showing target recognition in unrelated trials in bilingual infants (in English) but not in monolingual infants. We hypothesised that, as compared to the monolingual one, it might be due to the existence of stronger activation links or weaker inhibitory links in the bilingual lexicon. If this was the case, then, we expected to find word-to-word priming with the IPL task in bilingual infants as early as 18 months of age.

Secondly, in the use of cross-linguistic priming, it would be interesting to investigate the asymmetry of priming effect, namely, whether we would observe the same amount of forward (from L1 to L2) than backward (L2 to L1) priming. Classically, in bilingual adults who are not entirely proficient in L2, backward priming is stronger than forward priming, and the asymmetry is reduced with increased proficiency (Duñabeitia, Perea & Carreiras, 2010). In Exp.4 we examined whether such asymmetry could be found, depending on the level of exposure to L1 and L2; this would be taken as a proxy for a measure of proficiency.

Experiment 4: Lexical/Semantic Priming of 18 months-old Bilingual Infants

In this experiment, 18-month-olds, from various bilingual backgrounds (English plus any other Additional Language), were tested in a cross-linguistic version of the task used in Exp1: in half of the trials, the prime was presented in L1 and the target in L2, and the reverse for the other half of the trials.

Method

Participants

Participants were recruited from the Plymouth Babylab database. A total of 20 participants (14 girls, 6 boys) took part in this experiment with an average age of 18.3 months (range 17.4-20 months). At least one of the parents was a non-native speaker of English. An additional four children were excluded because one of them was trilingual (Spanish, Italian and English) and two did not want to participate. Another participant, English-Mandarin bilingual, was excluded after completion because it was found that the recordings of the Chinese stimuli were not of good quality.

Stimuli

The English stimuli which were used were similar to those used in Exp.1. In addition, we translated the stimuli into six languages with the help of native speakers when needed: Arabic, German, Spanish, Chinese (Mandarin), Dutch and Portuguese. Prior to the child's visit, the stimuli were recorded by a female native speaker in each language. We ensured that for all translations, the structure of the carrier sentence was such that it ended with the prime word. Each speaker recorded both the primes and the targets in her native language (see appendix B).

Procedure

The procedure used was the same as for Exp.1, except that each participant heard 12 trials with the prime in English and the target in their Additional Language, and the other 12 trials with the prime in their Additional Language and the target in English. For example, the English prime 'Yesterday I ate an apple' was followed by

the Arabic target word 'موزة'-'moza', meaning 'banana'). In another trial, the Arabic prime ('أمس رأيت قط' 'ams rait kiat', meaning 'Yesterday I saw a cat') was followed by the English target 'dog'. The order of the trials was randomised for each child (see Appendix B).

Estimates of Vocabulary

In this experiment, the English OCDI and the LEQ were used as well as, before the test, a parental check-list of words only in English. We removed any trials, in which the child did not know the word (prime, target) in English, together with the corresponding trials in the Additional Language. For example, if a child did not know 'apple', we removed the corresponding trial in English as well as the trial with its translation e.g. in German 'Apfel'. No BPVS or SETK were used since the children were too young for their vocabulary to be estimated with these tools.

Results

Sixty responses were excluded from 480 responses (corresponding to 20 times 24) since these trials consisted of words (priming or target) which participants did not know.

Twenty children's results were analysed in a repeated measure ANOVA with the two dependent variables being Priming Relation (related versus unrelated prime/target) and Prime Language (English versus Additional Language as the language of the prime) as within-participant factors.

For the longest look measure LLK, the main effect, of the Priming relation, was not significant ($F(1, 19) = 2.7$, $p = .12$, $\eta^2 = .12$) and the effect of the Prime Language was not significant either ($F(1, 19) = 2.84$, $p = .11$, $\eta^2 = .13$). No interaction was found

between Prime Language and Priming Relation (F (1, 19), p<1, η^2 = .045). In English primes, the average LLK was 526.7ms (t (19) = 4.48, p < .0001) in the related condition and 307.8ms (t (19) = 2.76, p = .012) in the unrelated condition; these were no different from each other (t (19) = 1.7, p = .11). When the prime was produced in the Additional Language, the average LLK was 216.9ms (t (19) = 2.01, p = .06) in the related condition and 192.0ms (t (19) = 1.6, p = .13) in the unrelated condition; these were no different from each other (t (19) < 1, Figure 10).

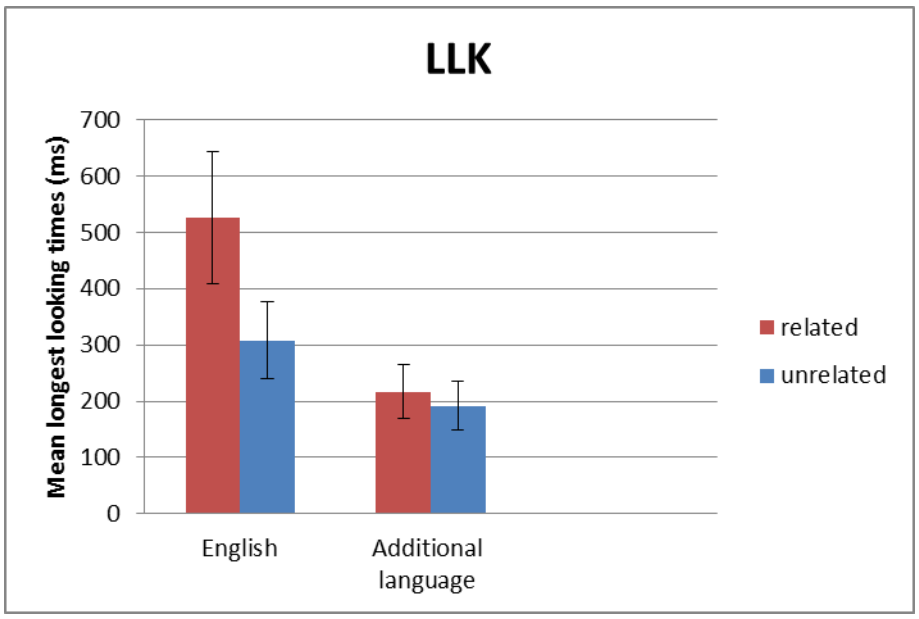


Figure 10: Mean LLK (MS) as a Function of Priming Relation (related and unrelated) and depending of the Language of the Prime (English versus Additional Language).

For the proportion of looks PTL, the main effect of the Priming relation was not significant (F (1, 19) = 1.52, η^2 = .07). Prime Language had no significant effect (F (1, 19) <1, η^2 = .04) and the interaction, between the Prime Language and the Priming Relation was not significant either (F (1, 19) <1, η^2 = .01; Figure 11). The average PTL with English primes was 14% (t (19) = 3.21, p < .005) in the related condition and 9% (t (19) = 2.58, p = .018) in the unrelated condition; these were

no different from each other (t (19) = 1.1). With the Additional Language primes, the average PTL was 8% (t (19) = 1.82, p = .08) in the related condition and 6% (t (19) = 1.2) in the unrelated condition; these were no different from each other (t (19) < 1; Figure 11).

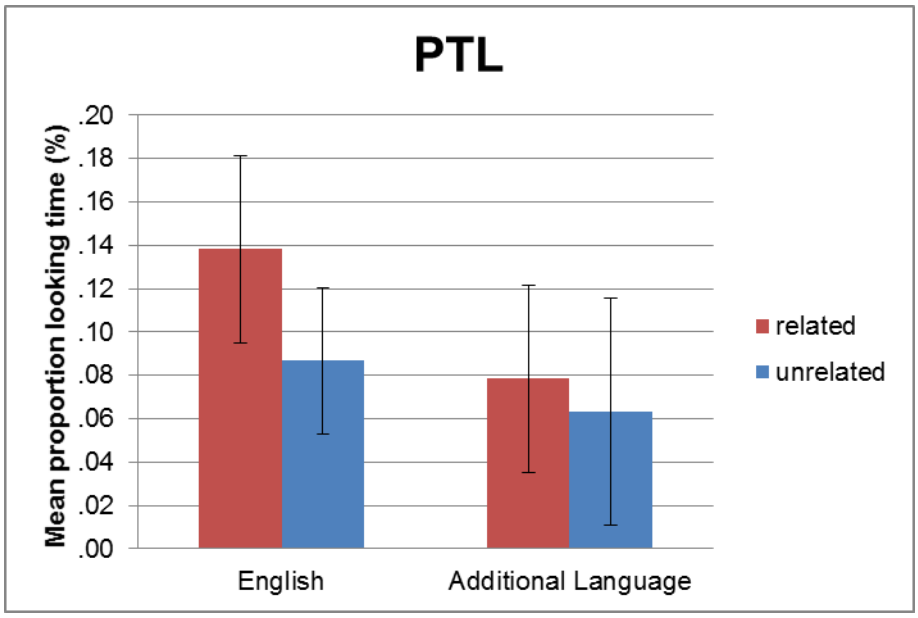


Figure 11: Mean PTL (%) as a Function of Priming Relation (related versus unrelated) and depending on the Language of the Prime (English versus Additional Language).

In a further analysis, we classified on the basis of their LEQ score, the children as being dominant in English or in the Additional Language. If a child scored 50% or above of English exposure, we classified him/her as English dominant. We found that 16 children were English-dominant and 4 were Additional-Language dominant. Since this ratio was too unbalanced, we could not compare the two sub-groups. However, we re-ran the above analyses excluding the 4 Additional-Language-dominant children (consequently, with only the 16 English-dominant children).

For the longest look measure LLK, the main effect of Priming Relation was insignificant (F (1, 15) = 3.57, p=.07, η^2 =.19). No effect of language was found (F(1, 15) = 3.31, p=.08, η^2 =.18), and no interaction was found between the Priming Relation and the Prime Language (F (1, 15)<1, η^2 = .07; Figure 12). The average LLK with English primes was 682.92ms in the related condition (t (15) = 5.83, p < .0001) and 406.81ms in the unrelated condition (t (15) = 3.23, p = .006); these were no different from each other (t (15) = 1.76). The average LLK with the Additional Language primes was 313.72ms in the related condition (t (15) = 2.91, p = .01) and 280.15ms in the unrelated condition (t (15) = 2.89, p = .01); these were no different from each other (t (15) < 1; Figure 12).

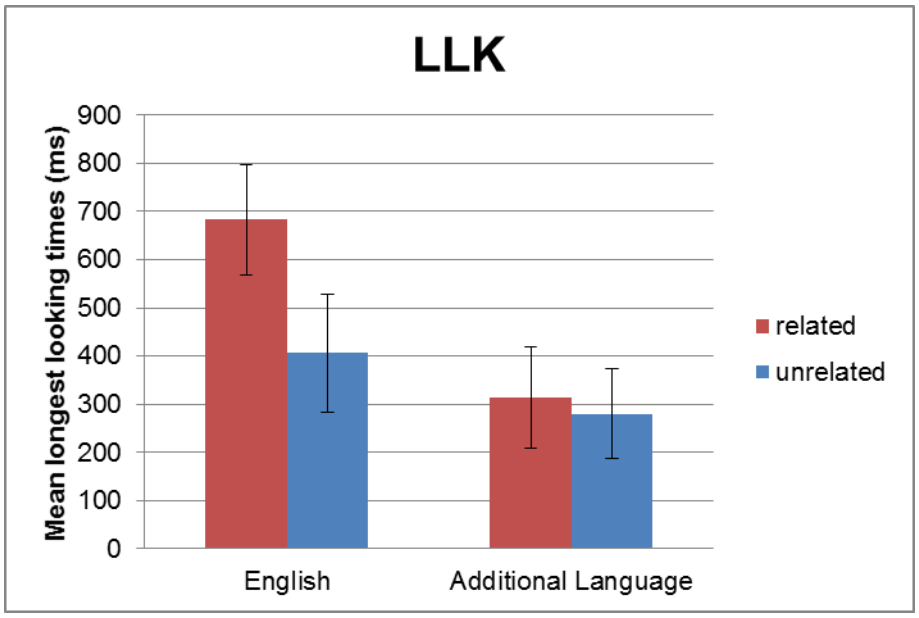


Figure 12: Mean LLK (MS) Times in Cross-linguistic Priming as a function of Priming Relation (related and unrelated) and Symmetry (English as Primes or Additional Language as Primes), for only the 16 English-dominant children

For the proportion of looks PTL, the main effect, of the Priming Relation was not significant (F (1, 15) = 2.32, p=.15, η^2 =.13). Prime Language did not have a

significant effect (F (1, 15) <1, η^2 =.01) and no interaction was found between the Priming Relation and the Prime Language. The average PTL with English primes was 20 % in the related condition (t (15) = 5.01, p <.0001) and 12 % in the unrelated condition (t (15) = 3.25, p = .005); these were no different from each other (t (15) = 1.49). With the Additional Language primes, the average PTL was 11% in the related condition (t (15) = 2.56, p = .02) and 8% in the unrelated condition (t (15) = 2.01, p = .06); these were no different from each other (t (15) <1; Figure 13).

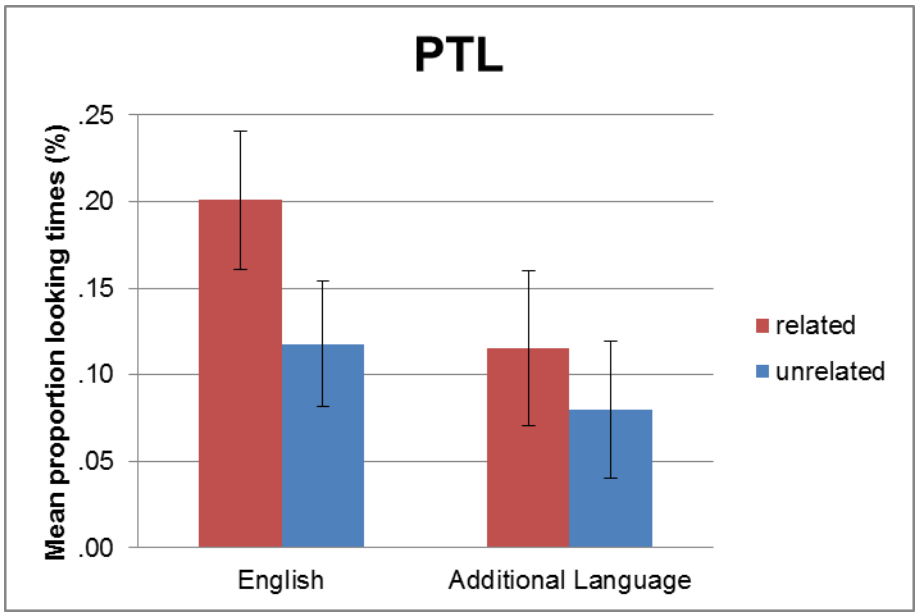


Figure 13: Mean PTL (%) Times in Cross-linguistic Priming as a Function of Priming Relation (related and unrelated) and Symmetry (English as Primes or Additional Language as Primes), for only the 16 English-dominant children.

Vocabulary Measures

Regarding the OCDI data, the mean comprehension CDI score was 69 words (SD= 23) out of 416 and the mean production OCDI was 25 words (SD=11). The mean LEQ to English was 57% (SD=11%).

There was no correlation either between the Additional Language Priming scores (mean LLK = 24.88, SD=557.94) and the English Priming score (mean LLK = 218.89, SD=574.64), or between the English Priming score or the Additional Language Priming score and the OCDI scores (Table 6). The LEQ scores correlated positively with all OCDI scores: comprehension (r=.52, p<.05), production (r=.73, p<.0001) and total (r=.72, p<.0001).

Table 6: Correlations between Priming Scores LLK; Age, Language Exposure Questionnaire (LEQ); and OCDI

	English LLK		Additional Language LLK	
	r	Sig	R	Sig
Age	.37	.11	-.05	.83
LEQ	-.02	.93	.65	.79
OCDI comprehension	-.03	.92	.33	.15
OCDI production	.13	.59	-.09	.72
Total OCDI	.03	.91	.25	.29

Table 7: Correlation between Priming Scores PTL; Age; Language Exposure Questionnaire (LEQ); and OCDI

	English PTL		Additional Language PTL	
	r	Sig	R	Sig
Age	.05	.83	.09	.69
LEQ	.21	.39	.12	.61
OCDI comprehension	-.11	.64	.29	.2
OCDI production	.35	.13	-.03	.9
Total OCDI	.04	.87	.24	.3

Discussion of Experiment 4

The purpose of this experiment was to examine whether 18 month old bilingual infants would show a semantic priming effect. Despite the fact that some studies had not found a semantic priming effect at the same age (e.g., Arias-Trejo & Plunkett, 2009; Styles & Plunkett, 2009), Delle Luche et al. (submitted) reported some evidence of semantic priming in monolingual children only18 months old when using a head-turn procedure . In addition, we checked whether there were asymmetries in looking times depending on the language of the prime. The main result of this experiment was that, irrespective of the priming condition (related or unrelated), bilingual 18-month-olds looked significantly longer at the target image; this was true regardless of the prime language (English versus Additional Language).

In addition, although not significant, the results suggest a tendency towards more forward priming (L1 to L2, with English being L1 for most children in this sample) than backward priming (L2 to L1). This is different from the results by Kroll and Stewart (1994) who found that translation from L2 to L1 led to stronger priming effects than from L1 to L2.

At this point, it seems that, even in bilingual infants who presumably could have stronger lexical connections than monolingual infants, the age of 18 months is, indeed, too early to observe robust priming effects. However, it remains possible that the lexicon of bilingual 18-month-olds might be more intra-connected than that of monolingual infants. This is not so much in terms of cross-linguistic connections, as tested here, but, simply, in terms of within-language connections (as seen in Exp.3 at 30 months). In order to gain a full picture of the priming

effects in bilingual and monolingual infants, Experiments 5 and 6 tested for the existence of a within-language semantic priming effect in monolingual 18-month-olds (Exp.5) and in bilingual 18-month-olds (Exp.6). Exp.5 was a simple control of similar experiments run by Plunkett and colleagues: since monolinguals were tested, no priming effect was expected. On the other hand, Exp.6 could reveal, potentially, priming effects in bilingual children.

Experiment 5: Lexical/Semantic Priming in18 months-old Monolingual Infants

In Exp.4, with regard to cross-language priming, we did not find significant priming effects in 18 month old-bilingual infants. This failure could be related to the young age of the participants since Styles and Plunkett (2009) also failed to report a priming effect with 18 month old monolingual infants. However, it could be due rather to the nature of the priming involved, namely, immature cross-linguistic links. In order to investigate this further, we tested, in English only, priming with monolingual and bilingual infants at the same age of 18 months. Exp.5 reports the results of testing priming in monolingual 18-month-old infants.

Method

Participants

The participants were 14 (9 males, 5 females) monolingual children aged 18 months (M=18.3 months; range = 17.2-20.4 months) recruited from the Plymouth Babylab database. Eight additional children (6 boys and 2 girls) were tested but were excluded due to researcher error (1); the child refusing to sit (1); and the removal of 6 children who knew less than 50% of the words.

Stimuli

We used the same stimuli as in Exp. 5.

Procedure

The procedure was the same as used in Exp. 4, the only difference was that each participant heard the primes and the targets in English. For example, in the related condition, 'Yesterday I ate an apple' was followed by the target word 'banana' and, then, by two pictures, a banana and a lion. In the unrelated condition, for example 'Yesterday I saw an elephant' was followed by 'car' and 'fridge'. The order of the trials was randomised for each child.

Results

Out of 336 expected responses, 74 responses were excluded due to the words (prime and/or target) not being known by the subject.

The results of 14 children were analysed in a repeated measure ANOVAs with Priming Relation (related versus unrelated prime/target) as a within participant factor.

For the longest look measure (LLK), the main effect of the Priming relation was not significant ($F(1, 13) < 1$, $\eta^2 = .04$). The average LLK was -95.3ms ($t(13) < 1$) in the related condition and -171.1ms ($t(13) < 1$) in the unrelated condition; these were no different from each other ($t(13) < 1$; see Figure 14).

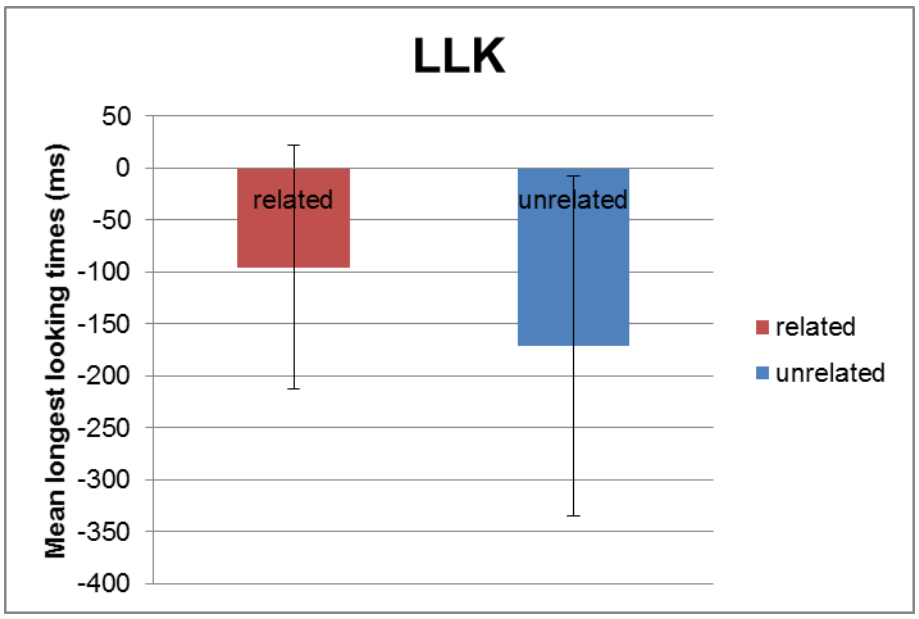


Figure 14: Difference in Mean Longest Looking Times (LLK) between Target and Distracter as a Function of the Priming Relation (related, unrelated)

For the PTL measure, the Priming relation did not have a significant effect either ($F(1, 13) < 1$, $\eta^2 = .004$). The average PTL was -7% ($t(13) < 1$) in the related condition and -8.5% ($t(13) < 1$) in the unrelated condition; these were no different from each other ($t(13) < 1$; see Figure 15).

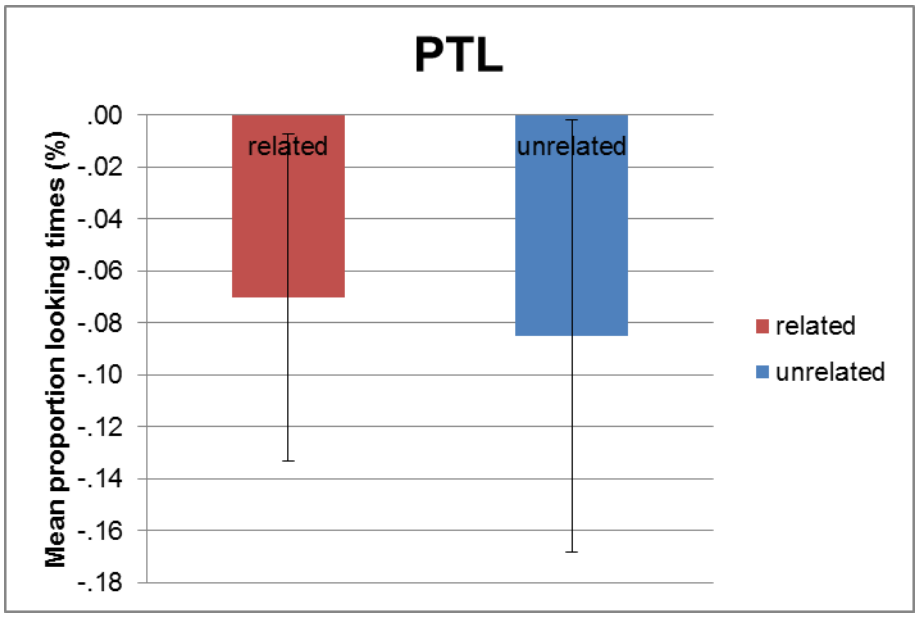


Figure 15: Mean Proportion Looking Times (PTL) as a Function of the Priming Relation (related versus unrelated)

Vocabulary Tests

The mean total OCDI score was 205 words (SD=91); the mean comprehension OCDI score was 179 words out of 416 (SD= 77) and the mean production OCDI score was 26 words (SD= 20) There was no correlation between the Priming Score (mean LLK = 75.78, SD=498.74; mean PTL = .014, SD=.25) and the OCDI (see Table 8).

Table 8: Correlation between Priming Score LLK; Age; and OCDI

	Priming LLK		Priming PTL	
	r	sig	r	Sig
Age	-.3	.35	-.2	.56
OCDI Comprehension	.15	.62	.15	.62
OCDI Production	.14	.63	.14	.63
Total OCDI	.15	.6	.15	.6

Discussion of Experiment 5

This fifth experiment was run to provide a benchmark for Exp.6, which was an exact replication of Exp.5 with bilingual infants. Indeed, we verified in Exp.5 that monolingual infants did not display any evidence of semantic priming using the IPL adaptation as in Arias-Trejo and Plunkett (2009). As expected, we did not observe any effect of semantic priming. The results were in line with Styles and Plunkett (2008, 2009) and Arias-Trejo and Plunkett (2009), whereas infants, at 18 months of age, showed no semantic priming effect, at least with the IPL procedure (for semantic priming in a head-turn procedure, see Delle Luche et al., submitted). This could be due to (1) infants, at this age, needing a longer time to recognise the

target as compared with older children; (2) word-word connections not being fully functional yet at around 18 months (but see Delle Luche et al., submitted) ; and (3) less familiarity with the test words at this age.

Having established the absence of semantic priming at 18 months in monolingual children, we turned now to a comparable group of 18 month old bilingual infants. If the presence of translation equivalents (e.g., 'dog'/'chien') was driving the earlier process in Exp.4, that is, no cross-linguistic priming, it remains possible that the bilingual lexicon at 18 months old be more connected within-languages altogether when compared to monolingual infants. Then we might expect semantic priming effects in this last experiment.

Experiment 6: Lexical/Semantic Priming in 18 month old Bilingual Infants

This sixth experiment was an exact replication of Exp.5, testing bilingual toddlers instead of monolingual infants. These children were learning English plus any other Additional Language. If the early bilingual lexicon was more intra-connected than the monolingual one, then we would expect to observe evidence of priming with this population.

Method

Participants

A total of 10 participants aged 18 months (4 boys, 6 girls) recruited from the Plymouth Babylab database took part in this experiment. They were bilingual infants with English and an Additional Language (Greek, French, German, Spanish, Italian, Malayalam and Polish) with an average age of 18 months (range 16.1-20.2 months). An additional 11 children were excluded for the following reasons: researcher error (1) and knowing less than 50% of the words (10).

Stimuli and procedure:

As used in Exp.5.

Results

Out of 240 expected responses, 63 responses were excluded due to the trials words (primes or target) not being known by the subject.

Ten children's results were analysed in a repeated measure ANOVA with Priming Relation (related versus unrelated prime/target) as a within participant factor.

In a first analysis, for the longest look measure (LLK) the main effect of the Priming relation was not significant (F (1, 9) <1, η^2 = .041). The average LLK was 42.1ms (t (9) < 1) in the related condition and -46.6ms (t (9) < 1) in the unrelated condition; these were no different from each other (t (9) <1; figure 16).

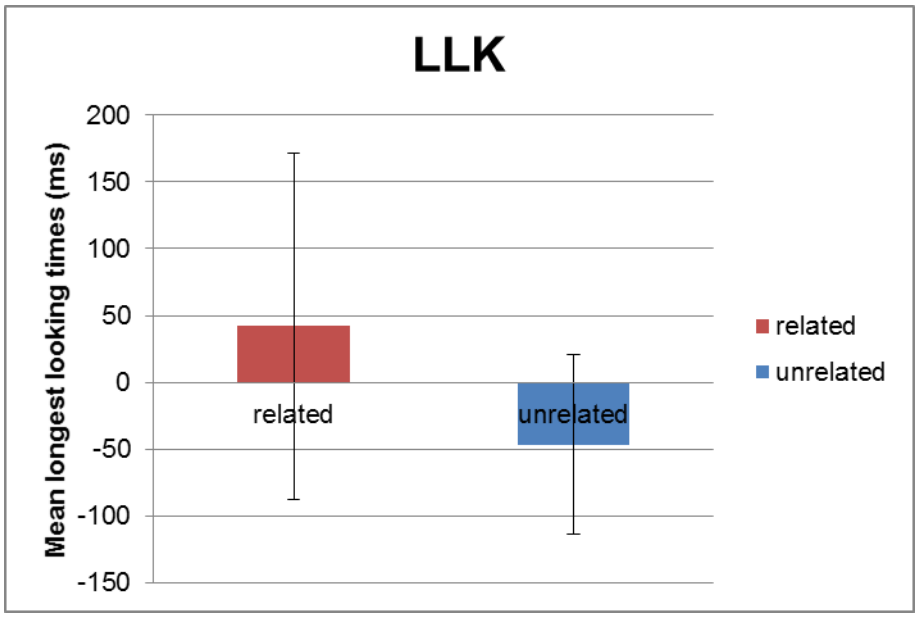


Figure 16: Difference in Mean Longest Looking Times (LLK) between Target and Distracter as a Function of the Priming Relation (related, unrelated)

For the PTL measure, the Priming relation did not have a significant effect either (F (1, 9) <1, η^2 =.008). Average PTL was 1.6% (t (9) < 1) in the related condition and -1.4% (t (9) < 1) in the unrelated condition; these were no different from each other (t (9) <1; figure17).

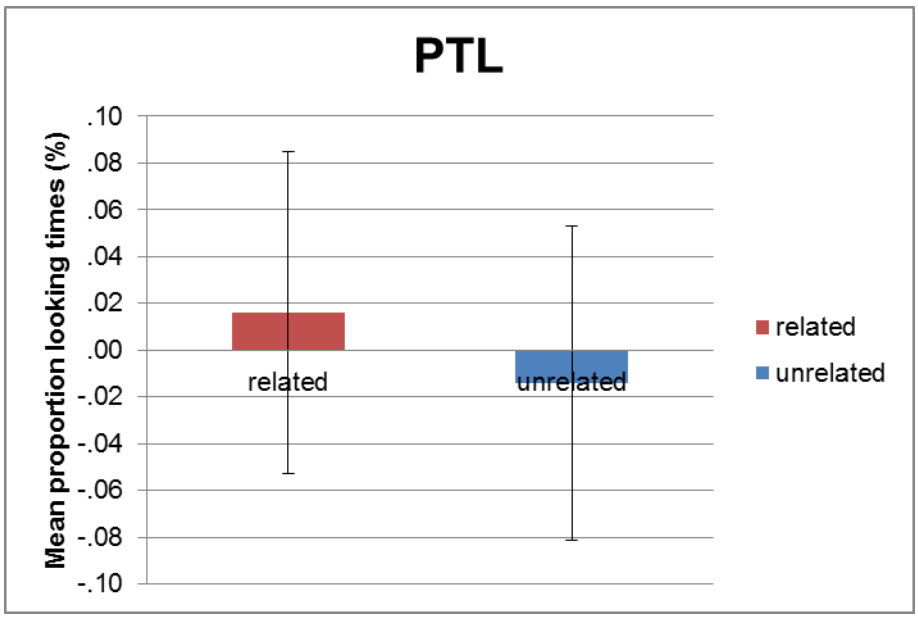


Figure 17: Mean Proportion Looking Times (PTL) as a Function of the Priming Relation (related versus unrelated)

Because of the small sample tested in Exp.6, we needed to ensure that what appeared to be with 10 children a null result, was indeed a null result, and not simply due to a small experimental power. For that purpose, we compared the means and standard deviations of LLK obtained in this experiment with the first 10 children tested in Exp.3 (30 month old bilingual Arabic –English infants; Table 9).

Table 9: The Means and Standard deviation of LLK between Exp 6 and Exp 3.

	Related		Unrelated	
	Mean	SD	Mean	SD
Exp 3 (30 mths)	**429.5**	**390.3**	**494.3**	**511.2**
Exp 6 (18 mths)	**42**	**409**	**-47**	**212**

Even with 10 participants, the naming effect appeared to be much stronger in Exp.3 than in Exp.6. Therefore, it was unlikely that more participants added to in Exp.6 would have made a significant difference to the size of the effects.

Vocabulary Tests

Regarding the OCDI data, the mean total OCDI score was 199 words (SD=91) out of 416; the mean comprehension OCDI score was 159 words (SD= 94); and the mean production OCDI score was 39 words (SD= 25).

According to the LEQ, the mean exposure to English was 61% (SD=13%).

There was no correlation between Priming Score (mean LLK = 88.63, SD= 454.45; mean PTL = .031, SD=.34) and the OCDI (see Table 10).

Table 10: Correlation amongst Priming Score LLK, Age and OCDI

	Priming LLK		Priming PTL	
	r	sig	r	Sig
Age	-.414	.234	.003	.99
LEQ	.281	.432	.21	.57
OCDI comprehension	.413	.236	.37	.29
OCDI production	.166	.647	.17	.73
OCDI cumulate	.476	.165	.42	.23

Discussion of Experiment 6

The main aim of this experiment was to investigate whether we could find a semantic priming effect with bilingual 18-month-olds when the prime and target were presented in the same language. Since Delle Luche et al. (submitted) had shown (with another technique) evidence of semantic relations in monolingual 18-month-olds, there was a possibility that bilingual children who had to connect words to one another more closely due to double-labelling, would show semantic priming at 18 months old with the classic Styles and Plunkett's (2009) paradigm. In Exp.5, we confirmed that, at 18 months of age with the IPL paradigm, no semantic priming could be obtained. Consequently, we asked whether or not this would extend also to bilingual infants.

In Exp.6, despite the small participant sample, it is clear that we failed to get semantic priming effect in bilingual 18-month-olds. Participants looked at the target and distracter images almost equally often in the two priming conditions (related, unrelated). When we compared the bilingual data with those from the first 10 participants tested in Exp.3 (30 month old bilingual infants), Exp.3's effect was clearly stronger than that found in Exp.6. It could be argued that the naming effect was more robust in Exp.3 than in Exp.6 because of the age difference between the two samples. However, altogether, the results were in line with the results of Exp.4 and Exp.5, and also with Plunkett et al.'s work with children under the age of 21 months (e.g., Arias-Trejo & Plunkett, 2009, 2013). Perhaps, a replication of Delle Luche et al. (submitted) with bilingual 18-month-olds, namely, with a head-turning paradigm, would allow the observation of priming effects and,

potentially, a comparison of the size effect between monolingual and bilingual populations.

Chapter four

General discussion

The primary aim of the work presented in this thesis was to advance our understanding of how bilingual infants build their lexical system. This was done by investigating across a series of 6 experiments the existence, within and across-languages, of a semantic relationship between words through the use of the Intermodal Preferential Looking (IPL) task.

The first two studies set up a benchmark for the subsequent ones by investigating the potential association between priming and target words (Exp.1) and priming words and target images (Exp.2) in monolingual 30-month-old infants. In addition, we assessed the relationship between the semantic priming effect and the size of vocabulary (production and comprehension). The third experiment searched for a semantic priming effect in bilingual 30-month-old infants and investigated whether this was related to vocabulary in each language. The fourth experiment examined, by using a cross-language design, the relationship between primes and targets in 18-month-old infants and explored the asymmetry between forward (L1 to L2) and backward (L2 to L1) priming. The fifth and sixth experiments investigated, only in English, the potential relationship between primes and target words in monolingual and bilingual 18-months-old infants. Across all these studies, we examined carefully the correlation between vocabulary (production and comprehension) and semantic priming scores.

In Exp.1, monolingual 30-month-old infants showed a robust effect of semantic priming, whereby they preferred to look towards the target rather than the

distracter image, but only when the target was preceded by a related word. In contrast, when the prime was unrelated to the target, no naming effect was found. This finding underlines the importance of relations between prime and target words, and is similar to what Plunkett and his colleagues reported from the age of 21 months. Here, what is intriguing, as well as in Styles and Plunkett (2009), is the absence of the naming effect in the unrelated condition. Namely, when presented with a prime followed by an unrelated target, children do not show a naming effect for the target as compared to the distracter's image. Arias-Trejo and Plunkett (2013) proposed that this behaviour is due to the inhibition of the target word by the unrelated prime. We will discuss this finding together with those of Exp.3 and 4, in which we found that bilingual children did not systematically behave similarly.

Findings from Exp.2 indicated that the presentation of the prime word alone (without the target word) was insufficient to drive lexical activation of the target. Namely, children were just as unlikely to identify the target image in the related condition as in the unrelated condition. This finding indicated that the prime word was not enough to drive target looking when it was not followed by a related target word.

As discussed in chapter 2, these findings are consistent with some of the previous studies in the area. Indeed, Styles and Plunkett (2009) found a semantic priming effect in 24 month old monolingual infants when they examined relationships between spoken words using IPL (see also Arias-Trejo & Plunkett, 2009). Furthermore, Styles and Plunkett (2011) did not find a semantic priming effect in 30-month-old infants when they presented them with word-picture trials. This result was in line with the finding from this thesis's second experiment. Having established firmly the existence of lexical-semantic priming at the age of 30

months in monolingual children, mainly driven by the relationships between prime and target words, we could turn then towards lexical-semantic links in the bilingual lexicon.

In Exp.3, bilingual 30-month-old infants showed the same pattern of preference as in Exp.1, namely a robust effect of semantic priming regardless of language (English, Arabic). In contrast, no naming effect was found when the target was preceded by the unrelated semantic prime, a result which appears similar to what was found in Exp.1. However, when each language was considered separately, the results were slightly different since although the mean looking times were higher in the related condition (not significantly though) in the English version of the task, bilinguals recognised the target irrespective of the priming condition. Conversely, in the Arabic task, the 30 month old bilingual infants recognised the target only when the target word came after the related semantic priming word. These findings suggest that bilingual 30-month-old infants are sensitive to the relationship between word pairs, at least in their dominant language (Arabic, in that case, as measured by the LEQ). However, the use of classical Arabic in the experimental task and in the vocabulary tests might be problematic in considering the Arabic results to be completely reliable. The Arabic language is made up of many dialects with lexical variations and therefore, children might have been presented often with lexical entries which they did not fully recognise. If one considers the English results to be more reliable than the Arabic ones, what is interesting is that, in the English task, looking times, for target recognition, are significantly above chance in the unrelated trials. This contrasts with Exp.1's results in which monolingual children, at the same age, did not show evidence of target recognition in unrelated trials.

Recently, Arias-Trejo and Plunkett (2013) proposed that the priming mechanisms, revealed in the IPL procedure, were not due to the prime words activating related target words ('dog' does not activate 'cat'), but rather to prime words inhibiting unrelated target words ('plate' inhibits 'cat'). This explains nicely the results of Exp.1, in which no naming effect was found in unrelated trials. However, it fails to explain what is seen in bilingual children in Exp.3 (in English). Indeed, it seems that in bilingual children an unrelated prime fails to completely inhibit the subsequent target as seen in monolinguals, which results in a naming effect for these words. Therefore, it is possible that bilingual children's lexicon contains less inhibitory links than that of the monolingual children, a suggestion which we evaluated in the next experiments.

In Exp.4, bilingual 18-month-old infants tested in a cross-linguistic version of the same task again looked longer at the target images irrespective of the priming condition (related, unrelated) when the prime was in English and when the prime was in the Additional Language. In addition, no semantic priming effect was found in any condition (prime in English and target in the Additional Language, or vice-versa). Various explanations can be proposed to explain this result. Firstly, this could be due to the immaturity of inhibitory links at 18 months old, resulting in the failure for primes to inhibit unrelated targets so that all targets became equally able to activate the related concept. This could be due, also, to 18-month-olds being unable, in such a restricted amount of time, to process semantic links.

These findings are consistent with some of previous work in the area for example Arias-Trejo and Plunkett (2009) and Styles and Plunkett (2009) who found that, in the two priming conditions (related, unrelated), 18 month old infants looked equally long to the target image over the distracter images. However, these results

are inconsistent with those obtained by Delle Luche et al. (submitted), who, by using a head-turn procedure in which children heard lists of related versus unrelated words, found a priming effect in 18 month old infants.

In this fourth experiment, we failed, also, to provide strong evidence for an asymmetric effect depending on the language of the prime and that of the target (L1 to L2 versus L2 to L1 priming), as was reported often in adults (e.g., Chen, Cheung & Lau, 1997). In order to perform this analysis, children were classified as English-dominant or Additional-Language dominant. This was done by calculating their amount of exposure over a recent typical week. Using this criterion, the majority, of the sample (16 out of 20) was English dominant (L1 = English). These children tended to show a stronger priming effect with forward priming (L1 primes and L2 targets) than backward priming (L2 primes and L1 targets) but not significantly so.

If these findings were to be confirmed with a larger sample, these pieces of data would be consistent with recent findings from Basnight-Brown and Altarriba (2007) who, in a Spanish-English bilingual population, reported semantic priming only in the L1-L2 direction and not in the L2-L1 direction. Previous cross-language priming studies (e.g., Keatley & de Gelder, 1992) had found robust semantic priming in both the L1–L2 and the L2–L1 directions whereas other research (e.g., Grainger & Beauvillain, 1988) had yielded non-significant semantic-priming results. Basnight-Brown and Altarriba (2007) argued that the reasons for these discrepancies might have been the lack of control of the bilinguals' background and the different values of Stimulus Onset Asynchrony (SOA).

It must be noted that, in paradigms using translation priming instead of semantic priming (namely, presenting an English-French bilingual with the prime 'cat'

followed by its French translation 'chat'), results usually go in the opposite direction in adults. For example, Kroll and Stewart (1994) found that the backward translation led to stronger priming effects than forward translation (see also Chen et al., 1997; but see de Groot & Poat, 1997 and Guasch, Sánchez-Casas, Ferré & García-Albea, 2011, for different patterns of results). In future research, it would be interesting to explore translation facilitation effects in young bilinguals, which might be more informative than semantic priming effects. Indeed, it is found usually that translation priming effects are stronger than semantic priming effects (e.g., Basnight-Brown & Altarriba, 2007); this might help to strengthen the results obtained so far.

Another avenue of interest would to be to quantify precisely in young bilinguals the amount of L1 and L2 to which they have been exposed since birth (instead of using a typical week measure as we did) and to examine how it relates to semantic priming effects. Silverberg and Samuel (2004) controlled carefully the level of proficiency and age of L2 acquisition in a group of Spanish-English speakers. They found that semantic priming (from L2 to L1: 'nail' primes 'tornillo', which means 'screw' in Spanish) could be obtained only in those who had acquired English earlier; this suggests that the semantic level of representation can be shared between the two languages only if the two languages are acquired early enough. It would be interesting to examine whether or not, depending on the age and rate of acquisition of L2, such differences between early and late learners can be observed already, to a certain extent, in infancy.

In Exp.5 in which semantic priming was evaluated in English only, the analysis revealed that, irrespective of the priming condition (related, unrelated), the 18 month old monolingual infants responded to the target and distracter images in

the same manner. Given previous studies, these results were not unexpected. For example, Arias-Trejo and Plunkett's (2009) and Styles and Plunkett's (2009) studies failed to show any semantic priming effect in 18 month old monolingual infants. However, it must be noted that, whereas we failed to report any naming effect in either condition, in these two former studies infants recognised the target images regardless of the fact that the target was preceded by related or unrelated prime words. Beside the sample size difference (55 in Arias-Trejo & Plunkett, 72 in Styles & Plunkett, 14 in the current Exp.5), our possible explanation is the size of the vocabulary differences between the two samples. Indeed, probably due to a sampling effect, the 18-month-old infants tested by Plunkett and colleagues had a mean receptive CDI score of 212 words and 51 words in production (Arias-Trejo & Plunkett, 2009) and 197 words in receptive vocabulary in Styles and Plunkett (2009). In contrast, our sample had a mean receptive score of 179 words and 26 in production. If children know fewer words, then not only the identification of prime and target words might be less reliable but, also, the semantic connections between them might be less well established.

However, when using an all-auditory head-turn procedure in which children heard lists of words from the same category (e.g., all animals or all food items), versus lists of items from two categories interwoven randomly (e.g., mix of animals and food items), Delle Luche et al. (submitted) found evidence of priming effect with children of the same age. Results showed that toddlers listened longer to the single category lists, suggesting that words from a given category activated one another. Therefore, it is difficult to explain exactly why children at the same age failed in the IPL task to show evidence of semantic priming. It could be because children were unable to compute semantic links fast enough to generate activation or inhibition

in the pairs of interest. It could be due also to infants not mastering most of the semantic relationships between the test words (they might have understood the meaning of the words as reported in their OCDI, without being able to relate words to one another; see Arias-Trejo & Plunkett, 2009, for this argument). This latter explanation would account nicely with our findings: in the IPL task, success in each trial rested on a single pair, whereas in the head-turn paradigm, each trial (or list) was made of many different words. Consequently, if a child failed to master the semantic relation between two particular words, e.g. 'cat' and 'dog', it would result in an uninformative trial in the IPL, and therefore, in a loss of statistical power. However, in the head-turn paradigm, it would be compensated by the fact that, within the same trial, another word might be presented which would be linked to either 'cat' or 'dog'.

In Exp.6, it was found also that bilingual 18 month old infants failed to show any semantic priming effect. In addition, infants failed. in both priming conditions, to show significant evidence of naming effect. Overall, 18 month old bilingual infants showed the same pattern of results as monolingual infants in Exp.5, where they demonstrated no target preference and failed to show significant evidence of semantic priming. To be on the safe side, these findings may indicate that, at least when measured in the IPL paradigm, either mono- or bilingual 18 month old infants have not yet developed fully associative or taxonomic relationships between words. Perhaps the use of the head-turn paradigm as in Delle Luche et al. (submitted) would be useful in clarifying whether or not priming effects could or could not be found in bilingual 18-month-old infants. It should be recalled that, because of the necessity from very early on to develop translation-equivalent

connections, we hypothesised that bilingual toddlers might develop word-to-word relationships or even semantic connections earlier than monolingual infants.

In experiments 1, 2, 4, 5 and 6, we did not obtain any significant correlation between semantic priming scores and size of vocabulary (production and comprehension). This provided a recurring pattern of results which was consistent with some previous studies (e.g., Arias-Trejo & Plunkett, 2009; Floccia et al., 2011; Havy & Nazzi, 2009; Killing & Bishop, 2008; Nazzi, 2005; Nazzi & New 2007; Swingley, 2003; Werker et al., 2002) which failed to report a link between lexical size and performance in word learning or word recognition tasks. However, it must be noted that some of the vocabulary measures such as the BPVS used in the current experiments, were measuring originally vocabulary for monolingual children older than 30 months. Therefore, there might be a floor effect in these vocabulary measures which would explain the overall lack of correlations with priming effects. In addition, it must be remembered that, compared to their monolingual peers, bilingual children have often less vocabulary in each language (Hoff & Elledge, 2005; Hoff et al., 2010; Oller et al., 2007; Pearson et al., 1993; Recorla & Achenbach, 2002; Vagh et al., 2009) which was also found in this study (Exp.3 as compared to Exp.1 and Exp.2). This might even accentuate the floor effect which was seen in online vocabulary tests.

Having said that, we did find, in Exp.3, a correlation between priming scores and some vocabulary measures. More specifically, a negative correlation was found between English priming scores and Arabic BPVS. We found also a marginally negative correlation between comprehension in the Arabic CDI and English priming scores (these correlations were in the same directions with the LLK and the PTL measures). The more words that were understood in Arabic, the less the

bilingual infants showed a priming effect in English. This suggests firstly that there might be a trade-off between the numbers of words which a bilingual child knows in each of his/her languages at 30 months; actually, such a trade-off was found by Cattani et al. (submitted). These authors examined the correlation between the amount of exposure to L1 (or L2) and the size of vocabulary in L1 (or L2) in toddlers aged 30 months (estimated, as in this study, with the CDI, the BPVS and the SETK). They found that the more exposure children received in one language (as estimated with the LEQ, similar to this study), the more words they knew.

In summary, the findings of Exp.1 and Exp.3 show clearly that, at 30 months of age and whether they learn one or two languages, children have developed semantic links between related words. The direction of effects in Exp. 4 suggests the emergence of such links in 18 month old bilingual infants, indicating that 18 month old infants have begun to understand the relationship between spoken words. In agreement with the adult literature, they suggest also that forward priming (L1 to L2) could be stronger than backward priming, as if, at that stage, the bilingual lexicon was already a miniature version of the mature, adult lexicon. In order to obtain a full picture of the developmental course of the early bilingual lexicon, further research is necessary to clarify the existence of semantic links in children aged 18 months and younger, and to evaluate the effects of priming through translation-equivalents and cognates.

Conclusion

In this thesis we offered a summary review of studies that have explored the linguistic processes and representations used by monolingual and bilingual infants when they start to process their language(s). The main conclusions derived from reviewing previous studies were that bilingual children are slower in developing

phonology and tend to experience some difficulties in acquiring some grammatical rules. Furthermore, the research indicated that bilinguals have less vocabulary compared with their monolingual peers, with regards to lexical representations. In spite of the fact that there are few studies that have examined this issue, there is some debate concerning the existence of a differentiated or a common representation system for the two languages.

Our experimental work was set out to explore how bilingual infants organise lexical entries in their two languages. Specifically, we examined lexical-semantic relationships between words within and across languages. The thesis has also sought to uncover relationships between semantic priming effects and vocabulary size. The main findings of this thesis suggest that bilingual infants at 30 months of age are sensitive to the semantic relation between words within each of their languages, however we found little evidence of a relationship between priming effects and vocabulary production and comprehension. At 18 months of age, results showed no evidence of priming whether it was tested across languages or within a single language, which rules out the possibility that the bilingual lexicon might be better intra-connected than the monolingual one.

In spite of what is often reported about a language delay in bilingual children, the findings in the present research suggests that bilingual infants may build a semantic network between words at the same time as their monolingual peers, even though they show a smaller vocabulary size in each of their languages when compared with monolinguals.

Future research should aim at clarifying the ontogeny of semantic networks in mono- and bilingual children, as well as the inter- and intra-language connectivity in the early bilingual lexicon. To address the first point, it would be interesting to

extend the use of the head-turn task (Delle Luche et al., submitted) to the investigation of lexical/semantic links as early as 18 months in bilingual children. This would allow to determine whether words can prime each other across and within languages in bilingual toddlers, and therefore reach some understanding about the nature of early semantic representations.

Regarding the second point, it remains unclear whether the bilingual lexicon is characterised by a combination of activating and inhibitory relations between words, both across and within languages. It would be necessary then to re-examine semantic priming at 30 months using the IPL paradigm and compare translation priming, cross-linguistic priming and within-language semantic priming, to get a full picture of the connectivity within the lexicon.

Finally, future research should also investigate the links between taxonomic and associative relationships in the lexicon of monolingual and bilingual toddlers (see Arias-Trejo & Plunkett, 2013, for monolinguals). It has been reported that bilingual children tend to show less detailed semantic knowledge of words (Verhallen & Schoonen, 1993), perhaps suggesting a delay in setting up taxonomic representations. This could be counterbalanced by a larger attention being paid to associative links between words, an empirical question that should be addressed in systematic comparisons between priming generated by taxonomically versus associatively related words.

Ultimately, these new avenues of research should allow us to get a better understanding of the early bilingual lexicon, which, in time, would allow a better knowledge of the specific problems encountered by young bilinguals with language difficulties (Bedore & Pena, 2008).

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Appendices

Appendix A: Vocabulary Measures
1: Object naming sub-test (adapted English SETK-2)

	Objects	Score (1 or 0)
1	Key	
2	doll, dolly, baby, child	
3	Knife	
4	ball, football,	
5	pencil, pen, felt tip, crayon, colourer	
6	book, picture book,	
	Pictures	
7	Car, types of car, e.g. VW	
8	Chair, seat,	
9	house, hut, villa, home, flat	
10	clock, alarm clock, tick tock	
11	Swing	
12	Tree	
13	Apple	
14	Fork	
15	scissors. Snip snip	
16	eyes. Eye	
17	duck, goose, quack quack,	
18	cup, beaker	
19	pig, oink oink, piglet, sow	
20	Bus	
21	Butterfly	
22	Pear	
23	Comb	
24	Star	
25	cake, muffin, bun	
26	bear, teddy, teddy bear, polar bear	
27	train,	
28	Brush	
29	Fridge	
30	petrol station, garage	
Total		

3: **Details of the calculation of E, percentage of exposure to English.**

A. Input from the parents:

Number of hours a week in English-speaking nursery/childminder/playgroup = N

Number of sleeping hours per night = S

Does the Mother always speak the Additional Language (AL) to the Child, or usually, or equally often English and the AL, or usually English, or always English (5 possible responses) = M

Does the Father always speak the Additional Language to the Child, or usually, or equally often English and the AL, or usually English, or always English (5 possible responses) = F

When together, who speaks most to the child? Mother, Father or Both = Most

Number of hours per week spent with Mother only = HM

Number of hours per week spent with Father only = HF

B. What does the calculation entail:

1. Assign a percentage to M and F, to estimate the proportion of English in each parent's input to the child.

If M (or F) = Always AL then ME (or FE) = 100

If M (or F) = Usually AL then ME (or FE) = 75

If M (or F) = Equally AL and English then ME (or FE) = 50

If M (or F) = usually English then ME (or FE) = 25

If M (or F) = always English then ME (or FE) = 0

2. Correct HM and HF to give more weight to the time spent with the Mother, as it is found usually that fathers tend to produce less verbal output to their child, therefore directly impacting on the amount of exposure in English and the Additional Language (e.g. Pancsofar & Vernon-Feagans, 2006).

Corrected time with Mother = CHM = HM*4/3

Corrected time with Father = CHF = HF*2/3

3. Assign a value (MI to Most, to give more weight to the Mother's input. What is obtained corresponds to the percentage of the Mother's input during the time when both parents are with the child.

If Most = Mother then MI = 90

If Most = Father then MI = 50

If Most = Both then MI = 70

4. Calculate the number of hours per week with both parents together

$$TBP = 7(24 - S) - N - HM - HF$$

5. Calculate the total number of hours of English exposure in a week (E) with the following formula:

E = English from mother when mother alone + English from father when father alone + English from mother when both parents together + English from father when both parents together + English from nursery or equivalent

$$E = \frac{CHM(100\text{-}ME)}{100} + \frac{CHF(100\text{-}FE)}{100} + N + 0.01 * TBP * \frac{MI(100\text{-}ME)}{100} + 0.01 * \frac{TBP(100\text{-}MI)(100\text{-}FE)}{100}$$ With

English from mother when mother alone = CHM(100-ME)/100

English from father when father alone = CHF(100-ME)/100

English from mother when both parents together = 0.01*TBP*MI(100-ME)/100

English from father when both parents together = 0.01*TBP(100-MI)(100-FE)/100

Calculate the percentage of exposure to English

$$P = \frac{E}{7(24 - S)}$$

Appendix B: Stimuli

Experiments 1, 2 and 3 stimuli

Target not presented in Exp.2.

English stimuli for Exp.3.

priming-carrier-sentence	Target	distracter	
yesterday I ate an apple	banana	lion	Related
yesterday I bought a shirt	banana	lion	Unrelated
yesterday I saw a bee	butterfly	bicycle	Related
yesterday I saw a bib	butterfly	bicycle	Unrelated
yesterday I saw a bib	baby	ball	Related
yesterday I bought a book	baby	ball	Unrelated
yesterday I saw a bird	duck	slide	Related
yesterday I bought a plate	duck	slide	Unrelated
yesterday I ate a biscuit	coat	monkey	Unrelated
yesterday I bought a watch	coat	monkey	Related
yesterday I bought a book	pen	carrot	Related
yesterday I saw a bird	pen	carrot	Unrelated
yesterday I bought a boot	door	frog	Unrelated
yesterday I saw a key	door	frog	Related
yesterday I saw a cat	dog	boat	Related
yesterday I ate an apple	dog	boat	Unrelated
yesterday I bought a cot	bed	chicken	Related
yesterday I saw a fish	bed	chicken	Unrelated
yesterday I saw an elephant	bus	trouser	Unrelated
yesterday I saw a lorry	bus	trouser	Related
yesterday I saw a fish	giraffe	balloon	Related
yesterday I bought a cot	giraffe	balloon	Unrelated
yesterday I saw a hand	shoe	toast	Unrelated
yesterday I bought a boot	shoe	toast	Related
yesterday I saw a key	owl	ice cream	Unrelated
yesterday I saw a penguin	owl	ice cream	Related

yesterday I saw a lorry	mouse	Table	unrelated
yesterday I saw a pig	mouse	Table	related
yesterday I saw a penguin	cake	Tree	unrelated
yesterday I ate a biscuit	cake	Tree	related
yesterday I saw a pig	car	Bowl	unrelated
yesterday I saw a train	car	Bowl	related
yesterday I bought a watch	flower	Eye	unrelated
yesterday I saw a bee	flower	Eye	related
yesterday I bought a plate	cup	Sock	related
yesterday I saw a sheep	cup	Sock	unrelated
yesterday I saw a sheep	cow	Bread	related
yesterday I bought a spoon	cow	Bread	unrelated
yesterday I bought a spoon	fork	Pear	related
yesterday I saw a tiger	fork	Pear	unrelated
yesterday I bought a shirt	pyjamas	Bottle	related
yesterday I saw a cat	pyjamas	Bottle	unrelated
yesterday I saw a tiger	bath	Orange	unrelated
yesterday I bought a toothbrush	bath	Orange	related
yesterday I saw a train	horse	Pushchair	unrelated
yesterday I saw an elephant	horse	Pushchair	related
yesterday I bought a toothbrush	foot	Aeroplane	unrelated
yesterday I saw a hand	foot	Aeroplane	related

Experiment 3 stimuli: Arabic version

distracter	**Target**	**prime-**
سفينة	كلب	أمس رأيت قط
أسد	موزة	أمس أكلت تفاحه
أيس كريم	بومة	أمس رأيت مفتاح
ثلاجة	سيارة	أمس رأيت أرنب
برتقاله	حمام	أمس رأيت نمر
جزر	قلم	أمس أشتريت كتاب
كرسي	حصان	أمس رأيت قطار
ضفدع	باب	أمس أشتريت حقيبة
قرد	جاكيت	أمس أكلت بسكويت

أمس رأيت خروف	بقرة	عيش
أمس رأيت شاحنة	فأر	طاولة
أمس أشتريت ملعقة	سكين	غرسة
أمس رأيت سمكة	زرافة	بالونة
أمس أشتريت ساعة	زهرة	عين
أمس أشتريت فرشة أسنان	قدم	طائرة
أمس أشتريت طبق	كوب	جورب
أمس رأيت يد	حذاء	جحش
أمس رأيت فيل	كرة	بنطلون
أمس أشتريت فستان	بيجامة	زجاجة
أمس أشتريت مريلة	طفل	حافلة
أمس أشتريت بطانية	سرير	دجاجة
أمس رأيت حمامة	كعكة	كمثره
أمس رأيت عصفور	بطة	مضرب
أمس رأيت نحلة	فراشة	دراجة

Experiment 3 stimuli: English translation equivalents to the Arabic stimuli

priming-carrier-sentence	Target	Distracter
yesterday I saw a cat	dog	boat
yesterday I ate an apple	dog	boat
yesterday I ate an apple	banana	lion
yesterday I bought a blanket	banana	lion
yesterday I saw a key	owl	ice cream
yesterday I saw a pigeon	owl	ice cream
yesterday I saw a rabbit	car	fridge
yesterday I saw a lorry	car	fridge
yesterday I saw a tiger	bath	orange
yesterday I bought a toothbrush	bath	orange
yesterday I bought a book	pen	carrot
yesterday I saw a bird	pen	carrot
yesterday I saw a train	horse	chair
yesterday I saw an elephant	horse	chair
yesterday I bought a bag	door	frog
yesterday I saw a key	door	Frog

yesterday I ate a biscuit	jacket	Monkey
yesterday I bought a watch	jacket	Monkey
yesterday I saw a sheep	cow	Bread
yesterday I bought a spoon	cow	Bread
yesterday I saw a lorry	mouse	Table
yesterday I saw a rabbit	mouse	Table
yesterday I bought a spoon	knife	Tree
yesterday I saw a tiger	knife	Tree
yesterday I saw a fish	giraffe	Balloon
yesterday I bought a dress	giraffe	Balloon
yesterday I bought a toothbrush	foot	Aeroplane
yesterday I saw a hand	foot	Aeroplane
yesterday I bought a plate	cup	Sock
yesterday I saw a sheep	cup	Sock
yesterday I saw a hand	shoe	Donkey
yesterday I bought a bag	shoe	Donkey
yesterday I saw an elephant	ball	Trouser
yesterday I saw a train	ball	Trouser
yesterday I bought a dress	pyjamas	Bottle
yesterday I saw a cat	pyjamas	Bottle
yesterday I bought a bib	baby	Bus
yesterday I saw a fish	baby	Bus
yesterday I bought a blanket	bed	Chicken
yesterday I bought a book	bed	Chicken
yesterday I bought a watch	flower	Eye
yesterday I saw a bee	flower	Eye
yesterday I saw a pigeon	cake	Pear
yesterday I ate a biscuit	cake	Pear
yesterday I saw a bird	duck	Bat
yesterday I bought a plate	duck	Bat
yesterday I saw a bee	butterfly	Bicycle
yesterday I bought a bib	butterfly	Bicycle

Experiment 4 stimuli in English

priming-carrier-sentence	target	distracter	
yesterday I bought a book	pen	carrot	Related
yesterday I saw a bird	pen	carrot	Unrelated
yesterday I saw a cat	dog	boat	Related
yesterday I ate an apple	dog	boat	Unrelated
yesterday I saw some glasses	bus	fish	Unrelated
yesterday I saw a train	bus	fish	Related
yesterday I saw a pigeon	cake	trouser	Unrelated
yesterday I ate a biscuit	cake	trouser	Related
yesterday I saw a train	mouse	pear	Unrelated
yesterday I saw a rabbit	mouse	pear	Related
yesterday I bought a blanket	bed	bat	Related
yesterday I saw a bee	bed	bat	Unrelated
yesterday I saw a chair	giraffe	balloon	Unrelated
yesterday I saw an elephant	giraffe	balloon	Related
yesterday I saw a key	owl	ice cream	Unrelated
yesterday I saw a pigeon	owl	ice cream	Related
yesterday I saw a tiger	bath	orange	Unrelated
yesterday I bought a toothbrush	bath	orange	Related
yesterday I bought a toothbrush	foot	aeroplane	Unrelated
yesterday I saw a hand	foot	aeroplane	Related
yesterday I saw a lorry	table	horse	Unrelated
yesterday I saw a chair	table	horse	Related
yesterday I bought a plate	cup	chicken	Related
yesterday I bought a blanket	cup	chicken	Unrelated
yesterday I bought some socks	shoe	grapes	Related
yesterday I bought a spoon	shoe	grapes	Unrelated
yesterday I ate an apple	banana	lion	Related
yesterday I bought some socks	banana	lion	Unrelated
yesterday I saw a sheep	cow	bread	Related
yesterday I bought a dress	cow	bread	unrelated
yesterday I saw a bee	butterfly	bicycle	related
yesterday I bought a bib	butterfly	bicycle	unrelated
yesterday I saw a bird	duck	slide	related

yesterday I bought a plate	duck	slide	unrelated
yesterday I ate a biscuit	monkey	coat	unrelated
yesterday I saw a tiger	monkey	coat	related
yesterday I saw an elephant	car	fridge	unrelated
yesterday I saw a lorry	car	fridge	related
yesterday I bought a dress	pyjamas	bottle	related
yesterday I saw a sheep	pyjamas	bottle	unrelated
yesterday I bought a spoon	fork	tree	related
yesterday I saw a cat	fork	tree	unrelated
yesterday I bought a bib	baby	ball	related
yesterday I bought a book	baby	ball	unrelated
yesterday I saw a rabbit	eye	flower	unrelated
yesterday I saw some glasses	eye	flower	related
yesterday I saw a hand	door	frog	unrelated
yesterday I saw a key	door	frog	related

Experiment 4 stimuli Arabic

distracter	**Target**	**priming-carrier-sentence**
جزر	قلم	أمس أشتريت كتاب
دجاجه	سرير	أمس أشتريت بطانية
كمثرى	فأر	أمس رأيت قطار
سمكة	حافلة	أمس رأيت نظارة
بنطلون	كعكة	أمس رأيت حمامه
بالون	زرافة	أمس رأيت كرسي
أيس كريم	بومة	أمس رأيت مفتاح
برتقال	حمام	أمس رأيت نمر
طائرة	قدم	أمس أشتريت فرشة أسنان
حصان	طاولة	أمس رأيت شاحنة
مضرب	كوب	أمس أشتريت صحن
عنب	حذاء	أمس أشتريت جورب
أسد	موزة	أمس أكلت تفاحة
عيش	بقرة	أمس رأيت خروف
دراجة	فراشة	أمس رأيت نحلة
زحليقة	بطة	أمس رأيت عصفور

أمس رأيت قط	كلب	سفينة
أمس أكلت بسكويت	قرد	جاكيت
أمس رأيت فيل	سيارة	ثلاجة
أمس أشتريت فستان	بيجامة	زجاجة
أمس أشتريت ملعقة	شوكة	غرسة
أمس أشتريت مريله	طفل	كرة
أمس رأيت أرنب	عين	زهره
أمس رأيت يد	باب	ضفدع

Experiment 4 stimuli in German

priming-carrier-sentence	**Target**	**Distracter**
Gestern kaufte ich ein Buch	Stift	Karotte
Gestern kaufte ich eine Decke	Bett	Huhn
Gestern sah ich einen Zug	Maus	Birne
Gestern sah ich eine Brille	Bus	Fisch
Gestern sah ich eine Taube	Kuchen	Hose
Gestern sah ich einen Sessel	Giraffe	Ballon
Gestern sah ich einen Schlüssel	Eule	Eiscreme
Gestern sah ich einen Tiger	Bad	Orange
Gestern kaufte ich eine Zahnbürste	Fuss	Flugzeug
Gestern sah ich einen Lastwagen	Tisch	Pferd
Gestern kaufte ich ein Teller	Tasse	Schläger
Gestern kaufte ich Socken	Schuhe	Weintrauben
Gestern ass ich einen Apfel	Banane	Löwen
Gestern sah ich ein Schaf	Kuh	Brot
Gestern sah ich eine Biene	Schmetterling	Fahrrad
Gestern sah ich einen Vogel	Ente	Rutsche
Gestern sah ich eine Katze	Hund	Boot
Gestern ass ich ein Plätzchen	Affen	Mantel
Gestern sah ich einen Elefanten	Auto	Kühschrank
Gestern kaufte ich ein Kleid	Pyjama	Flasche
Gestern kaufte ich einen Löffel	Gabel	Baum
Gestern kaufte ich ein Lätzchen	Baby	Ball

Gestern sah ich einen Hasen	Auge	Blume
Gestern sah ich eine Hand	Tür	Frosch

Experiment 4 stimuli in Portuguese

priming-carrier-sentence	**Target**	**distracter**
ontem, comprei um livro	caneta	cenoura
ontem, comprei um cobertor	cama	galinha
ontem, vi um comboio	rato	pereira
ontem, vi alguns óculos	autocarro	peixe
ontem, vi um Pombo	bolo	calças
ontem, vi uma cadeira	girafa	balão
ontem, vi uma chave	coruja	gelado
ontem, vi um tigre	banho	laranja
ontem, comprei uma escova de dentes	pé	avião
ontem, vi uma furgoneta	mesa	cavalo
ontem, comprei um prato	chávena	morcego
ontem, comprei meias	sapato	uvas
ontem, comi uma maçã	banana	leão
ontem, vi uma ovelha	vaca	pão
ontem, vi uma abelha	borboleta	bicicleta
ontem, vi um pássaro	pato	escorrega
ontem, vi um gato	cão	barco
ontem, comi uma bolacha	macaco	casaco
ontem, vi um elefante	automóvel	frigorífico
ontem, comprei um vestido	pijama	garrafa
ontem, comprei uma colher	garfo	árvore
ontei, comprei um babete	bebé	bola
ontem, vi um Coelho	olho	flor
ontem, vi uma mão	porta	Rã

Experiment 4 stimuli in Spanish

priming-carrier-sentence	**Target**	**Distracter**

ayer, compré un libro	bolígrafo	zanahoria
ayer, compré una manta	cama	Pollo
ayer, ví un trén	ratón	Pera
ayer, ví algunas gafas	autobús	Pez
ayer , ví una poloma	tarta	pantalones
ayer, ví una silla	jirafa	Globo
ayer, ví una llave	búho	Helado
ayer, ví un tigre	bañera	Naranja
ayer, compré un cepillo de dientes	pie	aeropuerto
ayer, ví un camion	mesa	Caballo
ayer, compré un plato	taza	murciélago
ayer, compré unos calcetines	zapatos	Uvas
ayer,comí una manzana	plátano	León
ayer, ví una oveja	vaca	Pan
ayer ví una abeja	mariposa	Bicicleta
ayer, ví un pájaro	pato	toboggan
ayer, ví un gato	perro	Barco
ayer, comí una galleta	mono	Abrigo
ayer, ví un elefante	coche	frigorífico
ayer, compré un vestido	pyjama	Botella
ayer compré una cuchara	tenedor	Árbol
ayer compré un babero	bebé	Pelota
ayer ví un conejo	ojo	Flores
ayer ví una mano	puerta	Rana

Experiment 4 stimuli in Dutch

priming-carrier-sentence	Target	distracter
gisteren kocht ik een boek	Pen	wortel
gisteren kocht ik een laken	Bed	kip
gisteren zag ik een trein	Muis	peer
gisteren zag ik een bril	Bus	vis
gisteren zag ik een duif	Tart	broek
gisteren zag ik een stoel	Giraf	ballon
gisteren zag ik een sleutel	Uil	ijs
gisteren zag ik een tijger	Bad	sinaasappel
gisteren kocht ik een tandenborstel	Voet	vliegtuig
gisteren zag ik een vrachtauto	Tafel	paard
gisteren kocht ik een bord	Beker	vleermuis
gisteren kocht ik sokken	Schoen	druiven
gisteren at ik een appel	Banana	leeuw
gisteren zag ik een schaap	Koe	brood
gisteren zag ik een bij	Vlinder	fiets
gisteren zag ik een vogel	Eend	glijbaan
gisteren zag ik een kat	Hond	boot
gisteren at ik een koekje	Aap	jas
gisteren zag ik een olifant	Auto	koelkast
gisteren kocht ik een jurk	Pyjama	fles
gisteren kocht ik een lepel	Vork	boom
gisteren kocht ik een slabbetje	Baby	bal
gisteren zag ik een konijn	Oog	bloem
gisteren zag ik een hand	Deur	kicker

Experiments 5 and 6 stimuli

priming-carrier-sentence	target	Distracter	
yesterday I bought a book	pen	carrot	related
yesterday I saw a bird	pen	carrot	unrelated

yesterday I saw a cat	dog	boat	Related
yesterday I ate an apple	dog	boat	Unrelated
yesterday I saw some glasses	bus	fish	Unrelated
yesterday I saw a train	bus	fish	Related
yesterday I saw a pigeon	cake	trouser	Unrelated
yesterday I ate a biscuit	cake	trouser	Related
yesterday I saw a train	mouse	pear	Unrelated
yesterday I saw a rabbit	mouse	pear	Related
yesterday I bought a blanket	bed	bat	Related
yesterday I saw a bee	bed	bat	Unrelated
yesterday I saw a chair	giraffe	balloon	Unrelated
yesterday I saw an elephant	giraffe	balloon	Related
yesterday I saw a key	owl	ice cream	Unrelated
yesterday I saw a pigeon	owl	ice cream	Related
yesterday I saw a tiger	bath	orange	Unrelated
yesterday I bought a toothbrush	bath	orange	Related
yesterday I bought a toothbrush	foot	aeroplane	Unrelated
yesterday I saw a hand	foot	aeroplane	Related
yesterday I saw a lorry	table	horse	Unrelated
yesterday I saw a chair	table	horse	Related
yesterday I bought a plate	cup	chicken	Related
yesterday I bought a blanket	cup	chicken	Unrelated
yesterday I bought some socks	shoe	grapes	Related
yesterday I bought a spoon	shoe	grapes	Unrelated
yesterday I ate an apple	banana	lion	Related
yesterday I bought some socks	banana	lion	Unrelated
yesterday I saw a sheep	cow	bread	Related
yesterday I bought a dress	cow	bread	Unrelated
yesterday I saw a bee	butterfly	bicycle	Related
yesterday I bought a bib	butterfly	bicycle	Unrelated
yesterday I saw a bird	duck	slide	Related
yesterday I bought a plate	duck	slide	Unrelated
yesterday I ate a biscuit	monkey	coat	unrelated
yesterday I saw a tiger	monkey	coat	related

yesterday I saw an elephant	car	fridge	unrelated
yesterday I saw a lorry	car	fridge	related
yesterday I bought a dress	pyjamas	bottle	related
yesterday I saw a sheep	pyjamas	bottle	unrelated
yesterday I bought a spoon	fork	tree	related
yesterday I saw a cat	fork	tree	unrelated
yesterday I bought a bib	baby	ball	related
yesterday I bought a book	baby	ball	unrelated
yesterday I saw a rabbit	eye	flower	unrelated
yesterday I saw some glasses	eye	flower	related
yesterday I saw a hand	door	frog	unrelated
yesterday I saw a key	door	frog	related

Appendix C: Measure of the stimuli (duration, pitch and intensity)

Experiment 1, 2 and 3; Measure of stimuli

prime-carrier-sentences	prime word	target	duration	pitch	intensity
Yesterday I ate an apple			1.66	253.16	69.50
	apple		0.61	204.87	62.94
		banana	0.48	214.39	66.87
Yesterday I saw a bee			1.52	243.85	79.67
	bee		0.49	238.74	77.51
		butterfly	0.62	228.77	80.35
Yesterday I saw a bib			1.34	239.77	69.97
	bib		0.37	241.65	69.57
		baby	0.43	237.50	68.72
Yesterday I saw a bird			1.47	244.30	71.20
	bird		0.45	251.92	71.92
		duck	0.25	255.27	74.12
Yesterday I ate a biscuit			1.51	237.91	71.26
	biscuit		0.51	230.56	68.05
		coat	0.49	247.74	68.73
Yesterday I bought a book			1.53	261.29	81.87
	book		0.51	280.17	81.70
		pen	0.32	202.73	84.69
Yesterday I bought a boot			1.55	239.72	85.99
	boot		0.43	237.04	82.85
		door	0.42	207.00	86.93
Yesterday I saw a cat			1.74	238.24	78.74
	cat		0.47	201.98	75.47

		dog	0.30	223.25	83.12
Yesterday I bought a watch			1.31	239.27	78.73
	watch		0.46	258.43	79.58
		flower	0.56	220.29	82.51
Yesterday I bought a cot			1.47	251.09	84.17
	cot		0.44	306.97	80.72
		bed	0.27	207.21	85.24
Yesterday I saw an elephant			1.77	233.35	67.73
	elephant		0.69	236.40	64.63
		bus	0.31	238.73	71.64
Yesterday I saw a fish			1.57	250.83	69.76
	fish		0.66	254.25	67.34
		giraffe	0.44	227.61	73.19
Yesterday I saw a hand			1.55	239.32	83.29
	hand		0.54	231.29	80.92
		shoe	0.35	226.35	89.77
Yesterday I saw a key			1.43	259.93	68.89
	key		0.32	257.97	65.16
		owl	0.41	215.70	72.57
Yesterday I saw a lorry			1.39	227.36	86.91
	lorry		0.49	222.27	88.05
		mouse	0.32	213.78	84.43
Yesterday I saw a penguin			1.59	237.84	80.92
	penguin		0.55	241.64	77.82
		cake	0.41	274.97	81.83
Yesterday I saw a pig			1.29	237.57	84.49
	pig		0.30	258.91	83.98
		car	0.38	247.01	88.38
Yesterday I bought a plate			1.75	243.48	69.11
	plate		0.45	238.58	65.38
		cup	0.29	310.77	68.81
Yesterday I saw a sheep			1.38	230.09	68.61
	sheep		0.33	218.01	59.46
		cow	0.38	217.65	73.09
Yesterday I bought a shirt			1.47	237.16	67.67
	shirt		0.57	208.48	66.32
		pyjamas	0.61	237.39	70.42
Yesterday I bought a spoon			1.51	251.18	67.39
	spoon		0.57	237.54	62.12
		fork	0.38	243.37	72.68
Yesterday I saw a tiger			1.57	245.71	71.47
	tiger		0.55	246.57	71.91
		bath	0.30	221.54	76.45
Yesterday I saw a train			1.54	216.57	68.58
	train		0.41	190.97	67.94
		horse	0.21	201.82	72.79
Yesterday I bought a			1.71	251.80	68.63

toothbrush					
	toothbrush		0.69	245.56	64.92
		foot	0.36	253.62	70.94

Experiment 3 Measure of stimuli: Arabic version

priming-carrier-sentences	priming word	target	duration	pitch	intensity
yesterday I ate an apple			2.28	241.90	66.26
	apple		1.07	270.37	66.11
		banana	0.53	247.58	71.26
yesterday I saw a lorry			2.30	244.40	67.38
	lorry		0.72	274.92	67.67
		mouse	0.50	294.84	72.92
yesterday I saw a bee			2.07	250.64	69.14
	bee		0.56	265.45	68.98
		butterfly	0.73	297.50	73.80
yesterday I bought a bib			2.35	262.39	71.28
	bib		0.66	274.22	74.38
		baby	0.45	289.00	71.15
yesterday I saw a bird			2.29	259.51	68.73
	bird		0.83	271.37	69.05
		duck	0.52	287.72	71.81
yesterday I ate a biscuit			2.24	262.05	70.59
	biscuit		1.16	288.88	70.71
		jacket	0.56	280.75	70.92
yesterday I bought a blanket			2.22	243.79	68.75
	blanket		1.00	263.39	68.03
		bed	0.58	284.04	71.74
yesterday I bought a book			2.35	245.11	69.48
	book		0.51	271.21	71.23
		pen	0.45	256.20	73.01
yesterday I saw a cat			2.46	220.39	64.00
	cat		0.43	287.35	67.90
		dog	0.32	275.43	71.96
yesterday I bought a plate			2.47	236.85	68.21
	plate		0.53	249.80	69.42
		cup	0.32	314.67	74.39
yesterday I bought a dress			2.16	247.12	70.17
	dress		0.88	270.84	69.28
		pyjamas	0.64	273.61	71.71
yesterday I saw an elephant			2.45	250.08	69.07
	elephant		0.62	266.51	70.38
		bus	0.41	301.76	70.11
yesterday I saw a fish			2.06	261.00	70.65

	fish		0.72	289.91	70.35
		giraffe	0.75	275.27	73.67
yesterday I bought a bag			2.47	266.51	67.61
	bag		0.56	279.33	69.61
		door	0.26	295.17	75.98
yesterday I saw a key			2.29	278.23	70.07
	key		0.97	306.30	70.80
		owl	0.47	337.63	76.52
yesterday I saw a hand			2.38	245.53	67.63
	hand		0.73	258.73	67.48
		shoe	0.43	410.36	71.29
yesterday I saw a pigeon			2.35	243.80	68.69
	pigeon		0.66	265.14	69.13
		cake	0.46	275.06	72.05
yesterday I saw a rabbit			2.03	255.14	70.88
	rabbit		0.47	271.03	74.29
		car	0.77	271.49	72.75
yesterday I saw a sheep			2.07	244.73	67.49
	sheep		0.69	264.78	68.15
		cow	0.55	226.93	68.55
yesterday I bought a spoon			2.01	249.77	69.62
	spoon		0.64	283.59	70.28
		knife	0.79	309.22	69.97
yesterday I saw a tiger			2.10	268.21	69.94
	tiger		0.54	278.43	70.92
		bath	0.70	297.22	70.65
yesterday I bought a toothbrush			2.33	279.80	69.31
	toothbrush		1.10	295.42	68.41
		foot	0.47	280.97	73.93
yesterday I saw a train			2.17	245.91	68.89
	train		0.54	267.01	72.45
		horse	0.63	262.38	69.66
yesterday I bought a watch			2.22	260.69	70.69
	watch		0.62	308.46	72.19
		flower	0.58	270.16	72.65

Experiment 4 Measure of stimuli: English

prime-carrier-sentences	Prime word	target	duration	pitch	intensity
yesterday I ate an apple			1.64	213.83	72.25
	apple		0.46	194.43	67.57
		banana	0.65	197.76	74.75
yesterday I saw a cat			1.59	229.37	72.56

	cat		0.51	237.61	71.97
		dog	0.35	206.2	76.72
yesterday I saw a sheep			1.42	203.67	72.23
	sheep		0.36	242.23	69.90
		cow	0.51	190.02	73.47
yesterday I bought some socks			1.75	235.79	74.87
	socks		0.62	247.72	74.84
		shoe	0.54	211.79	78.63
yesterday I bought a plate			1.43	214.05	74.49
	plate		0.31	235.95	74.72
		cup	0.47	263.71	69.30
yesterday I bought a blanket			1.83	206.14	72.86
	blanket		0.69	195.76	70.22
		bed	0.38	192.87	78.30
yesterday I saw a train			1.60	195.00	72.37
	train		0.53	213.18	72.76
		mouse	0.68	209.77	78.11
yesterday I saw a lorry			1.61	193.09	73.66
	lorry		0.50	206.35	74.30
		table	0.57	216.78	77.70
yesterday I saw some glasses			1.83	205.90	71.37
	glasses		0.68	217.95	70.25
		bus	0.46	202.82	72.61
yesterday I saw a pigeon			1.58	202.67	75.14
	pigeon		0.55	203.89	73.78
		cake	0.32	161.49	73.54
yesterday I saw an elephant			1.75	207.01	73.72
	elephant		0.56	212.06	70.97
		car	0.55	182.39	74.10
yesterday I ate a biscuit			1.67	205.62	73.80
	biscuit		0.57	207.34	68.13
		monkey	0.56	198.21	74.52
yesterday I saw a bee			1.57	188.72	74.73
	bee		0.41	207.54	73.60
		butterfly	0.72	188.06	73.45
yesterday I saw a bird			1.56	195.72	73.19
	bird		0.51	205.79	73.77
		duck	0.40	240.99	75.68
yesterday I bought a book			1.51	212.23	72.72
	book		0.39	248.18	74.21
		pen	0.51	153.40	72.89
yesterday I bought a spoon			1.58	210.53	72.61
	spoon		0.66	329.01	71.86
		fork	0.61	181.77	72.69
yesterday I bought a dress			1.67	206.95	72.70
	dress		0.53	213.01	72.76
		pyjamas	0.62	212.93	76.01

yesterday I bought a bib			1.45	200.43	73.69
	bib		0.33	203.53	72.62
		baby	0.58	206.74	77.37
yesterday I bought a chair			1.56	229.31	69.40
	chair		0.51	232.08	67.19
		giraffe	0.41	177.57	61.79
yesterday I saw a key			1.53	211.58	73.13
	key		0.42	222.05	71.09
		owl	0.45	187.80	73.19
yesterday I saw a hand			1.62	197.88	72.76
	hand		0.61	204.04	70.68
		door	0.52	196.64	74.93
yesterday I saw a tiger			1.64	185.18	72.59
	tiger		0.59	179.45	72.07
		bath	0.53	229.01	69.41
yesterday I bought a toothbrush			1.69	209.24	74.87
	toothbrush		0.74	208.61	70.50
		foot	0.40	212.23	74.24
yesterday I saw a rabbit			1.58	212.48	70.89
	rabbit		0.50	175.97	72.10
		eye	0.48	185.95	75.62

Experiment 4 Measure of stimuli: Arabic

prime-carrier-sentences	prime word	target	duration	pitch	intensity
yesterday I ate an apple			1.74	209.57	71.96
	apple		0.61	201.37	67.23
		banana	0.97	198.54	76.04
yesterday I saw a cat			1.60	224.68	72.52
	cat		0.54	223.89	71.70
		dog	0.58	227.51	75.69
yesterday I saw a sheep			2.10	213.33	70.84
	sheep		0.76	218.87	68.45
		cow	0.50	187.40	69.23
yesterday I bought some socks			2.53	208.03	67.89
	socks		0.87	203.76	67.60
		shoe	0.50	212.30	69.43
yesterday I bought a plate			1.64	219.45	73.91
	plate		0.38	235.77	73.87
		cup	0.63	209.05	76.66
yesterday I bought a blanket			1.84	207.03	72.82
	blanket		0.63	202.20	70.54
		bed	0.83	191.12	74.23
yesterday I saw a train			1.62	195.76	72.31
	train		0.56	211.23	72.58
		mouse	0.64	191.27	72.34

yesterday I saw a lorry			1.61	195.87	73.67
	lorry		0.52	207.03	74.19
		table	0.55	185.09	77.13
yesterday I bought some glasses			2.21	199.92	70.95
	glasses		0.81	196.23	70.75
		bus	0.49	203.25	69.34
yesterday I saw a pigeon			2.15	206.84	73.94
	pigeon		0.69	211.53	73.30
		cake	0.27	167.54	75.90
yesterday I saw an elephant			2.02	207.21	74.87
	elephant		0.57	198.75	75.82
		car	0.54	181.82	74.08
yesterday I ate a biscuit			1.69	206.61	73.76
	biscuit		0.57	214.04	68.14
		monkey	0.58	198.71	74.81
yesterday I saw a bee			2.06	207.59	74.41
	bee		0.59	215.30	74.25
		butterfly	0.72	187.75	73.47
yesterday I saw a bird			1.55	197.32	73.22
	bird		0.52	205.20	73.72
		duck	0.52	204.79	74.66
yesterday I bought a book			2.12	208.11	73.07
	book		0.64	208.56	71.28
		pen	0.51	147.45	72.89
yesterday I bought a spoon			1.58	212.20	72.59
	spoon		0.63	221.13	71.91
		fork	0.63	216.92	72.61
yesterday I bought a dress			1.70	207.08	72.59
	dress		0.60	211.54	72.45
		pyjamas	0.83	184.75	76.17
yesterday I bought a bib			2.62	189.98	75.56
	bib		0.84	200.60	77.77
		baby	0.58	207.75	77.40
yesterday I bought a chair			1.57	227.56	69.38
	chair		0.52	231.40	67.13
		giraffe	0.83	190.10	70.44
yesterday I saw a key			1.98	206.77	73.55
	key		0.75	208.70	73.02
		owl	0.45	185.30	73.20
yesterday I saw a hand			1.63	231.87	73.51
	hand		0.68	233.49	72.15
		door	0.51	197.54	74.98
yesterday I saw a tiger			1.65	184.67	72.58
	tiger		0.59	180.88	72.07
		bath	0.72	196.26	76.14
yesterday I bought a toothbrush			2.85	207.33	72.68

	toothbrush		1.13	205.03	72.76
		foot	0.40	257.52	74.26
yesterday I saw a rabbit			2.12	192.61	74.64
	rabbit		0.61	193.17	73.90
		eye	0.48	188.05	75.61

Experiment 4 Measure of stimuli: German

prime-carrier-sentences	prime word	target	duration	pitch	intensity
yesterday I ate an apple			1.57	226.72	69.60
	cat		0.50	235.69	69.02
		dog	0.40	199.33	71.37
yesterday I saw a cat			2.07	253.94	71.85
	sheep		0.61	175.85	65.28
		cow	0.50	189.48	70.81
yesterday I saw a sheep			1.72	209.70	70.58
	apple		0.60	201.21	65.90
		banana	0.61	158.05	73.23
yesterday I bought some socks			2.00	272.30	71.69
	socks		0.54	191.21	69.58
		shoe	0.50	212.53	73.21
yesterday I bought a plate			1.50	214.30	72.04
	plate		0.39	237.76	71.54
		cup	0.62	152.30	70.74
yesterday I bought a blanket			1.83	204.76	72.25
	blanket		0.63	202.15	70.02
		bed	0.30	172.13	75.35
yesterday I saw a train			1.62	197.96	71.93
	train		0.55	211.77	72.27
		mouse	0.53	182.94	73.06
yesterday I saw a lorry			1.62	195.72	72.24
	lorry		0.57	206.03	72.93
		table	0.41	199.55	73.00
yesterday I bought some glasses			2.18	245.98	71.51
	glasses		0.50	177.23	69.46
		bus	0.49	203.36	70.95
yesterday I saw a pigeon			2.01	249.08	72.41
	pigeon		0.53	161.56	71.26
		cake	0.31	157.14	73.84
yesterday I saw an elephant			2.08	259.41	73.23
	elephant		0.81	219.50	71.36
		car	0.55	182.45	71.42
yesterday I ate a biscuit			1.67	205.33	71.80
	biscuit		0.57	213.99	66.11
		monkey	0.58	189.29	72.88
yesterday I saw a bee			1.90	266.31	72.05

	bee		0.37	192.72	66.23
		butterfly	0.72	188.00	71.71
yesterday I saw a bird			1.55	196.49	72.03
	bird		0.52	205.52	72.55
		duck	0.59	198.23	72.86
yesterday I bought a book			2.01	271.95	70.63
	book		0.38	187.66	63.03
		pen	0.53	150.20	71.68
yesterday I bought a spoon			1.58	212.09	71.14
	spoon		0.71	220.17	70.10
		fork	0.42	177.57	72.75
yesterday I bought a dress			1.70	208.92	71.60
	dress		0.60	212.90	71.62
		pyjamas	0.81	172.10	72.57
yesterday I bought a bib			2.03	245.52	73.50
	bib		0.42	191.50	69.79
		baby	0.56	208.56	73.63
yesterday I bought a chair			1.57	227.56	70.37
	chair		0.51	231.28	68.15
		giraffe	0.56	173.64	72.11
yesterday I saw a key			2.18	263.27	71.59
	key		0.56	195.23	66.28
		owl	0.45	185.16	71.97
yesterday I saw a hand			1.93	256.90	71.75
	hand		0.44	198.47	66.40
		door	0.51	197.91	73.83
yesterday I saw a tiger			1.63	183.69	70.62
	tiger		0.58	180.59	70.14
		bath	0.65	166.28	70.24
yesterday I bought a toothbrush			2.36	266.68	69.90
	toothbrush		0.87	190.51	66.64
		foot	0.40	252.23	71.57
yesterday I saw a rabbit			2.18	253.54	70.34
	rabbit		0.56	198.50	66.33
		eye	0.48	185.79	70.39

Experiment 4 Measure of stimuli: Dutch

prime-carrier-sentences	prime word	target	duration	pitch	intensity
yesterday I ate an apple			1.60	224.22	70.87
	cat		0.61	201.37	67.23
		dog	0.27	174.50	73.74
yesterday I saw a cat			1.69	193.20	70.71
	sheep		0.50	160.03	70.41
		cow	0.50	186.92	73.64

yesterday I saw a sheep			1.74	207.88	71.49
	apple		0.76	218.87	68.45
		banana	0.54	152.18	71.53
yesterday I bought some socks			1.59	212.83	70.59
	socks		0.87	203.76	67.60
		shoe	0.49	214.97	73.02
yesterday I bought a plate			1.42	209.98	70.78
	plate		0.38	235.77	73.87
		cup	0.39	179.23	67.74
yesterday I bought a blanket			1.73	208.91	76.12
	blanket		0.53	201.84	74.35
		bed	0.49	180.88	71.24
yesterday I saw a train			1.63	195.35	69.16
	train		0.56	210.70	69.45
		mouse	0.52	146.92	64.48
yesterday I saw a lorry			1.59	195.30	73.12
	lorry		0.50	207.46	73.79
		table	0.57	194.54	73.21
yesterday I bought some glasses			1.86	205.73	70.78
	glasses		0.81	196.23	70.75
		bus	0.49	203.43	71.85
yesterday I saw a pigeon			1.96	202.99	73.37
	pigeon		0.32	171.19	77.14
		cake	0.26	171.92	77.50
yesterday I saw an elephant			2.19	198.54	71.78
	elephant		0.57	198.75	75.82
		car	0.55	181.20	71.09
yesterday I ate a biscuit			1.66	205.19	70.81
	biscuit		0.57	214.04	68.14
		monkey	0.31	190.98	74.69
yesterday I saw a bee			1.92	188.38	69.18
	bee		0.59	215.30	74.25
		butterfly	0.73	187.87	69.31
yesterday I saw a bird			1.55	196.07	70.23
	bird		0.52	205.20	73.72
		duck	0.27	167.38	72.71
yesterday I bought a book			2.00	209.29	71.87
	book		0.64	208.56	71.28
		pen	0.51	149.59	76.65
yesterday I bought a spoon			1.60	210.27	70.55
	spoon		0.64	217.77	69.82
		fork	0.48	193.09	68.99
yesterday I bought a dress			1.73	207.37	71.12
	dress		0.60	211.54	72.45
		pyjamas	0.55	184.42	70.38
yesterday I bought a bib			2.06	202.79	76.34

	bib		0.84	200.60	77.77
		baby	0.57	206.75	76.63
yesterday I bought a chair			1.57	227.97	72.36
	chair		0.52	231.40	67.13
		giraffe	0.34	206.53	70.12
yesterday I saw a key			1.99	213.07	69.29
	key		0.69	188.71	67.22
		owl	0.46	187.55	73.54
yesterday I saw a hand			1.88	215.68	73.54
	hand		0.56	195.36	74.22
		door	0.51	197.86	77.86
yesterday I saw a tiger			1.65	195.91	73.15
	tiger		0.58	190.53	72.96
		bath	0.30	197.71	72.45
yesterday I bought a toothbrush			2.24	196.53	66.99
	toothbrush		0.89	167.10	67.27
		foot	0.51	256.35	69.90
yesterday I saw a rabbit			2.32	206.34	68.95
	rabbit		0.52	149.59	73.74
		eye	0.48	188.12	71.10

Experiment 4 Measure of stimuli: Portuguese

prime-carrier-sentences	prime word	target	duration	pitch	intensity
yesterday I ate an apple			1.74	252.72	72.09
	cat		0.47	192.22	68.68
		dog	0.35	185.92	71.06
yesterday I saw a cat			1.42	201.23	70.22
	sheep		0.37	201.13	67.85
		cow	0.61	200.88	71.37
yesterday I saw a sheep			1.65	211.78	72.17
	apple		0.56	192.43	67.57
		banana	0.49	218.27	74.41
yesterday I bought some socks			1.88	250.25	70.02
	socks		0.61	181.40	67.98
		shoe	0.53	215.34	68.56
yesterday I bought a plate			1.46	215.41	70.46
	plate		0.38	196.33	69.92
		cup	0.52	167.18	69.35
yesterday I bought a blanket			1.85	207.89	71.60
	blanket		0.63	202.01	70.35
		bed	0.38	209.99	75.43
yesterday I saw a train			1.62	194.76	72.31
	train		0.54	211.75	72.71
		mouse	0.58	212.79	70.48
yesterday I saw a lorry			1.60	195.95	73.83
	lorry		0.44	203.62	74.78

		table	0.66	279.22	74.58
yesterday I bought some glasses			1.85	207.35	71.29
	glasses		0.73	190.97	70.12
		bus	0.68	195.78	73.61
yesterday I saw a pigeon			1.62	201.00	74.29
	pigeon		0.54	204.37	73.29
		cake	0.42	203.00	77.67
yesterday I saw an elephant			1.81	209.37	75.13
	elephant		0.61	181.22	73.01
		car	0.52	197.69	73.30
yesterday I ate a biscuit			1.68	202.70	68.56
	biscuit		0.58	191.00	62.81
		monkey	0.63	195.59	66.65
yesterday I saw a bee			1.79	206.25	78.13
	bee		0.60	193.22	78.17
		butterfly	0.73	188.13	74.76
yesterday I saw a bird			1.84	255.08	71.20
	bird		0.59	209.27	68.92
		duck	0.40	195.64	66.64
yesterday I bought a book			2.00	207.70	73.35
	book		0.96	203.39	74.48
		pen	0.49	146.81	72.42
yesterday I bought a spoon			1.64	193.17	67.67
	spoon		0.68	181.42	66.94
		fork	0.80	196.92	68.84
yesterday I bought a dress			1.72	208.07	67.94
	dress		0.66	202.98	67.75
		pyjamas	0.67	184.01	74.62
yesterday I bought a bib			2.01	204.84	75.97
	bib		0.70	200.34	75.07
		baby	0.58	205.71	75.54
yesterday I bought a chair			1.57	197.61	72.80
	chair		0.51	191.74	71.34
		giraffe	0.76	195.96	74.02
yesterday I saw a key			2.27	213.05	71.61
	key		0.77	187.86	67.45
		owl	0.49	184.91	71.80
yesterday I saw a hand			1.55	213.86	69.60
	hand		0.47	192.81	68.68
		door	0.52	196.47	68.76
yesterday I saw a tiger			1.68	192.75	68.53
	tiger		0.62	183.79	67.91
		bath	0.49	181.51	71.81
yesterday I bought a toothbrush			2.36	201.38	76.38
	toothbrush		0.76	199.79	67.92
		foot	0.44	207.54	73.02
yesterday I saw a rabbit			1.95	201.48	73.37
	rabbit		0.66	200.87	75.28

		eye	0.47	185.76	69.20

Experiment 4 Measure of stimuli: Spanish

prime-carrier-sentences	prime word	target	duration	pitch	intensity
yesterday I ate an apple			1.57	226.98	69.60
	cat		0.50	236.34	68.99
		dog	0.46	207.55	72.19
yesterday I saw a cat			1.80	214.83	70.76
	sheep		0.58	221.02	70.48
		cow	0.51	189.92	70.45
yesterday I saw a sheep			1.74	215.91	71.95
	apple		0.50	193.46	67.17
		banana	0.76	218.80	72.19
yesterday I bought some socks			2.25	222.07	74.17
	socks		0.83	205.46	70.72
		shoe	0.42	215.29	76.40
yesterday I bought a plate			1.47	210.29	71.32
	plate		0.33	238.49	71.46
		cup	0.37	212.54	72.00
yesterday I bought a blanket			1.83	206.26	69.83
	blanket		0.63	198.80	67.54
		bed	0.38	227.92	70.48
yesterday I saw a train			1.63	197.89	71.28
	train		0.56	211.70	71.57
		mouse	0.64	232.72	73.61
yesterday I saw a lorry			1.65	198.68	73.56
	lorry		0.51	207.27	74.27
		table	0.51	262.36	74.76
yesterday I bought some glasses			1.72	231.31	71.96
	glasses		0.56	232.19	71.13
		bus	0.48	202.77	71.42
yesterday I saw a pigeon			1.78	221.27	72.38
	pigeon		0.50	201.89	73.28
		cake	0.25	179.17	74.39
yesterday I saw an elephant			1.70	231.17	75.53
	elephant		0.72	213.49	74.99
		car	0.55	180.99	75.40
yesterday I ate a biscuit			1.68	205.50	70.78
	biscuit		0.56	206.99	65.16
		monkey	0.40	227.39	72.92
yesterday I saw a bee			1.57	228.97	71.39
	bee		0.42	210.73	70.19
		butterfly	0.73	187.80	70.78

yesterday I saw a bird			1.57	196.22	75.20
	bird		0.51	206.11	75.77
		duck	0.39	227.71	75.98
yesterday I bought a book			2.07	230.60	76.83
	book		0.43	208.94	74.55
		pen	0.49	152.79	77.40
yesterday I bought a spoon			1.60	212.05	70.56
	spoon		0.67	219.99	69.78
		fork	0.58	225.47	72.89
yesterday I bought a dress			1.74	206.97	70.82
	dress		0.54	211.70	71.03
		pyjamas	0.58	245.70	73.14
yesterday I bought a bib			1.69	215.86	74.40
	bib		0.49	206.64	76.26
		baby	0.59	207.11	74.37
yesterday I bought a chair			1.57	229.40	71.37
	chair		0.52	232.14	69.10
		giraffe	0.89	207.77	70.77
yesterday I saw a key			1.49	225.23	75.26
	key		0.47	217.36	76.90
		owl	0.46	187.42	76.46
yesterday I saw a hand			1.63	232.81	75.40
	hand		0.45	235.96	75.08
		door	0.53	197.45	75.08
yesterday I saw a tiger			1.63	191.47	69.61
	tiger		0.59	183.59	69.07
		bath	0.52	208.89	72.28
yesterday I bought a toothbrush			1.65	204.43	74.97
	toothbrush		0.73	238.47	70.55
		foot	0.54	208.73	75.75
yesterday I saw a rabbit			1.82	231.15	75.31
	rabbit		0.50	209.52	71.65
		eye	0.48	185.70	73.48

Experiment 5 and 6; Measure of stimuli

prime-carrier-sentences	Prime word	target	duration	pitch	intensity
yesterday I ate an apple			1.64	213.83	72.25
	apple		0.46	194.43	67.57
		banana	0.65	197.76	74.75
yesterday I saw a cat			1.59	229.37	72.56
	cat		0.51	237.61	71.97
		dog	0.35	206.2	76.72

yesterday I saw a sheep			1.42	203.67	72.23
	sheep		0.36	242.23	69.90
		cow	0.51	190.02	73.47
yesterday I bought some socks			1.75	235.79	74.87
	socks		0.62	247.72	74.84
		shoe	0.54	211.79	78.63
yesterday I bought a plate			1.43	214.05	74.49
	plate		0.31	235.95	74.72
		cup	0.47	263.71	69.30
yesterday I bought a blanket			1.83	206.14	72.86
	blanket		0.69	195.76	70.22
		bed	0.38	192.87	78.30
yesterday I saw a train			1.60	195.00	72.37
	train		0.53	213.18	72.76
		mouse	0.68	209.77	78.11
yesterday I saw a lorry			1.61	193.09	73.66
	lorry		0.50	206.35	74.30
		table	0.57	216.78	77.70
yesterday I saw some glasses			1.83	205.90	71.37
	glasses		0.68	217.95	70.25
		bus	0.46	202.82	72.61
yesterday I saw a pigeon			1.58	202.67	75.14
	pigeon		0.55	203.89	73.78
		cake	0.32	161.49	73.54
yesterday I saw an elephant			1.75	207.01	73.72
	elephant		0.56	212.06	70.97
		car	0.55	182.39	74.10
yesterday I ate a biscuit			1.67	205.62	73.80
	biscuit		0.57	207.34	68.13
		monkey	0.56	198.21	74.52
yesterday I saw a bee			1.57	188.72	74.73
	bee		0.41	207.54	73.60
		butterfly	0.72	188.06	73.45
yesterday I saw a bird			1.56	195.72	73.19
	bird		0.51	205.79	73.77
		duck	0.40	240.99	75.68
yesterday I bought a book			1.51	212.23	72.72
	book		0.39	248.18	74.21
		pen	0.51	153.40	72.89
yesterday I bought a spoon			1.58	210.53	72.61
	spoon		0.66	329.01	71.86
		fork	0.61	181.77	72.69
yesterday I bought a dress			1.67	206.95	72.70
	dress		0.53	213.01	72.76
		pyjamas	0.62	212.93	76.01
yesterday I bought a bib			1.45	200.43	73.69
	bib		0.33	203.53	72.62

		baby	0.58	206.74	77.37
yesterday I bought a chair			1.56	229.31	69.40
	chair		0.51	232.08	67.19
		giraffe	0.41	177.57	61.79
yesterday I saw a key			1.53	211.58	73.13
	key		0.42	222.05	71.09
		owl	0.45	187.80	73.19
yesterday I saw a hand			1.62	197.88	72.76
	hand		0.61	204.04	70.68
		door	0.52	196.64	74.93
yesterday I saw a tiger			1.64	185.18	72.59
	tiger		0.59	179.45	72.07
		bath	0.53	229.01	69.41
yesterday I bought a toothbrush			1.69	209.24	74.87
	toothbrush		0.74	208.61	70.50
		foot	0.40	212.23	74.24
yesterday I saw a rabbit			1.58	212.48	70.89
	rabbit		0.50	175.97	72.10
		eye	0.48	185.95	75.62